APPENDIX E: Economics

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APPENDIX E - ECONOMICS

HAMILTON CITY FLOOD DAMAGE REDUCTION AND ECOSYSTEM RESTORATION PROJECT

This economics appendix summarizes a revised flood damage analysis performed for the Hamilton City Flood Damage Reduction and Ecosystem Restoration Project. The first evaluation was conducted in October 2001 as part of Sacramento & San Joaquin River Basins Comprehensive Study. This appendix focuses upon the evaluation of without- and with-project flood damage and the benefits of alternative plans to reduce flood damage. Ecosystem restoration benefits, project costs and plan formulation are found in Chapter 3 (Alternative Plans) in the main report and Appendix A (Plan Formulation).

The economic evaluation was performed in accordance with ER 1105-2-100 (Planning Guidance Notebook) and ER 1105-2-101 (Risk-Based Analysis for Evaluation in Flood Damage Reduction Studies). The analysis was based on a 50-year period of analysis, October 2003 price levels and a Federal discount rate of 5 5/8%. The earliest the project could become operational is estimated to be the fall of 2008.

E.1 BACKGROUND

The U.S. Army Corps of Engineers and The Reclamation Board of the State of California are conducting a feasibility study to develop and evaluate potential alternative plans to reduce flood damages and restore the ecosystem along the Sacramento River near Hamilton City. The goal of the study is to identify a cost effective, technically feasible, and locally acceptable project that best meets the dual objectives of reducing flood damages and restoring the ecosystem and is in compliance with all Federal, State, and local laws and regulations. The study will culminate in completion of an integrated feasibility report and environmental impact statement / environmental impact report (EIS/EIR) documenting the study findings. The intent is to submit the report to Congress for authorization to implement the project. The costs to conduct the study and implement a project are shared between Federal, State, and local interests. State and/or local interests are responsible for operation and maintenance of the project, if implemented.

E.1.1 Study Area Description

Hamilton City is located in Glenn County, California, along the right (west) bank of the Sacramento River, about 85 miles north of the City of Sacramento. The study area includes Hamilton City and the surrounding rural area. The study area is bounded by the Sacramento River to the east and the Glenn Colusa Canal to the west and extends about two miles north and six miles south of Hamilton City. In 2000, Hamilton City had a population of about 1,900, up from about 1,810 in 1990 and about 1,340 in 1980 (CA Dept of Finance). Estimated 1999 Hamilton City per capita income is about $9,050 (US Census), much less than the 1999 Glenn County per capita income of about $18,015 or the California average of about $29,910 (CA Dept of Finance). Surrounding land use is agricultural with fruit and nut orchards being the primary crops.

An existing private levee, constructed by landowners in about 1904 and known as the "J" Levee, provides some flood protection to the town and surrounding area. The "J" Levee is not constructed to any formal engineering standards and is largely made of silty sand. It is extremely susceptible to erosion and floodfighting is often necessary to prevent flooding when river levels rise. Since the construction of Shasta Dam in 1945, flooding in Hamilton City due to problems with the "J" Levee has occurred once (1974) causing about $50,000 in damage and about $22,000 in levee repair costs (current year dollars).[1] In addition, extensive floodfighting has been necessary to avoid flooding in 1983, 1986, 1995, 1997, and 1998. Currently, the Sacramento River is actively eroding into the toe of the levee at the northern end of the study area. Glenn County has built a backup levee, about 1,000 feet in length, to protect the community in the event the toe erosion causes failure at the northern end of the "J" Levee.

Native habitat and natural river function in the study area have been altered by construction of the "J" Levee and conversion of the floodplain to agriculture and rural development. The "J" Levee and bank protection (typically with rock) constrain the river's ability to meander and overflow its banks to promote propagation and succession of native vegetation. Conversion of the floodplain to agriculture and rural development reduced the extent of native habitat to remnant patches along the river and in historic oxbows. These alterations to the ecosystem have greatly diminished the abundance, richness, and complexity of riparian, wetland, and floodplain habitat in the study area and the species dependent upon that habitat.

Regional location and study area maps are provided in Figures 1 and 2.

[1] This damage was caused by inadequate levee maintenance that allowed floodwater to back up into orchards and the southeastern part of town rather than a failure of the levee itself. Although past reports do not indicate the estimated frequency of this event, they do indicate that the flow was 181,000 cfs, which equates to about a 7% event based upon the 2003 hydrologic analysis.

Figure 1
Regional Location Map

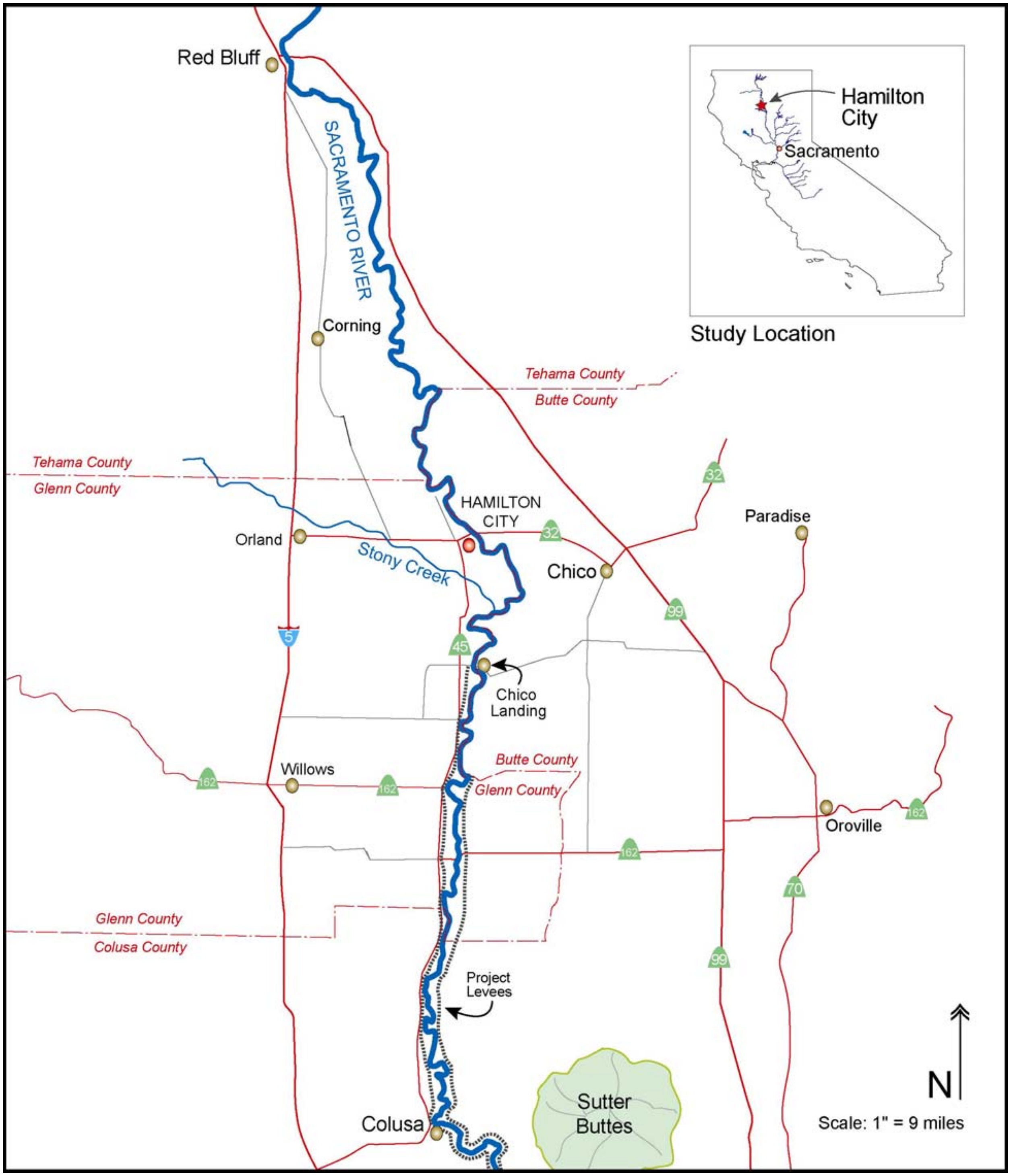
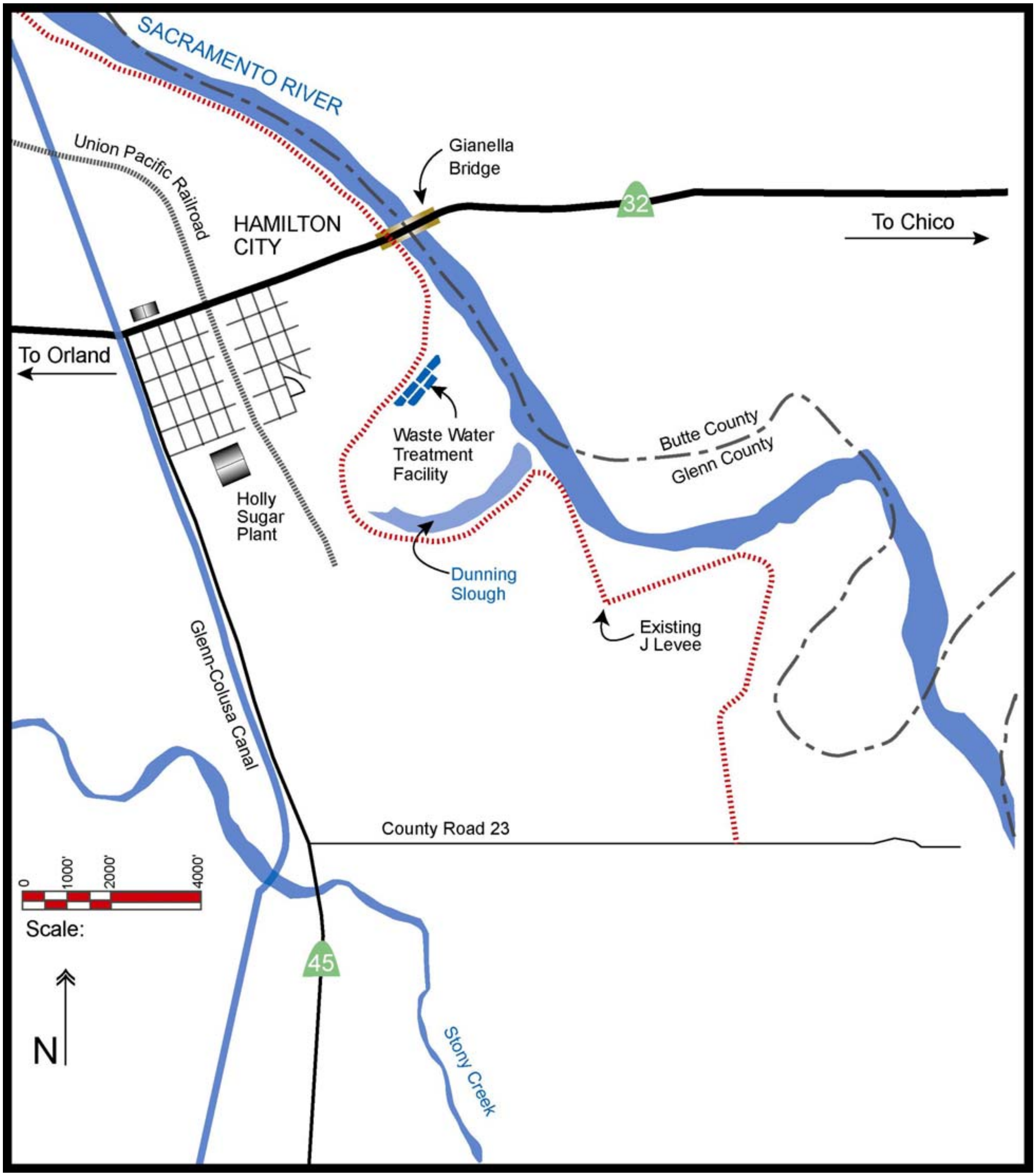


Figure 2
Study Area Map



E.1.2 Changes from the 2001 Economic Analysis

This revised 2003 economic analysis incorporates numerous significant changes to the original analysis that was conducted in 2001. These changes include:

- **Hydrology and Hydraulics (H&H)** —the H&H models were revised to be site-specific for the Study Area. Changes included: (1) an evaluation of local storm centerings, (2) a wider range of storm events and (3) different levee failure assumptions on the left (east) and right (west) banks of the Sacramento River. The original index point of 198.61 was moved downstream to 198.25 to avoid problems with water surface elevations (WSE) being unduly influenced by the nearby Gianella Bridge. Two additional index points were assigned downstream to more accurately define the site-specific hydraulic and geotechnical relationships.
- **Impact areas** — study areas are typically subdivided into impact areas (also known as damage reaches) to facilitate the flood damage analysis by taking into account differing flooding problems and land uses. In the 2001 economic analysis, only one impact area was used (Hamilton City) which incorporated the town itself and agricultural lands immediately north and south of town. However, for this revised analysis, three impact areas were identified to better account for differing flood problems – Northern (index point at river mile 198.25), Southern #1 (index point at river mile 197.25) and Southern #2 (index point at river mile 194.25), as shown in Figure 3. The economic impact areas were delineated based upon the 500-year, or 0.2% event (2003) hydrology. Although the town itself and agricultural areas immediately north and south of town are protected by the existing "J" Levee, further south, there is no levee and agricultural lands are directly threatened by higher-velocity overland flows from the river. Further complicating the flooding issue is the presence of backwater flooding, which can flow around the southern end of existing (and proposed) levees and flood agricultural lands to the north. The division into three impact areas also improves the analysis of crop flood damage compared to the original economic analysis.
- **Analysis zones** - The impact areas were further divided into analysis zones (A through L) to facilitate the flood damage analysis for different levee setback alternatives (Figure 3). The Northern impact area contains analysis zones F through L; Southern #1 contains D and E; and Southern #2 includes A, B and C. Conditions in a zone could remain unchanged (i.e., same as the future without-project condition), the zone could be protected by a new levee, the zone could be converted from agriculture to native habitat (eliminating most flood damage), or a flowage easement could be purchased within the zone to compensate for induced flooding (caused by breaching the existing "J" Levee).

Changes in technical models and assumptions are summarized in Table 1.

Figure 3
Economic Analysis Impact Areas and Analysis Zones

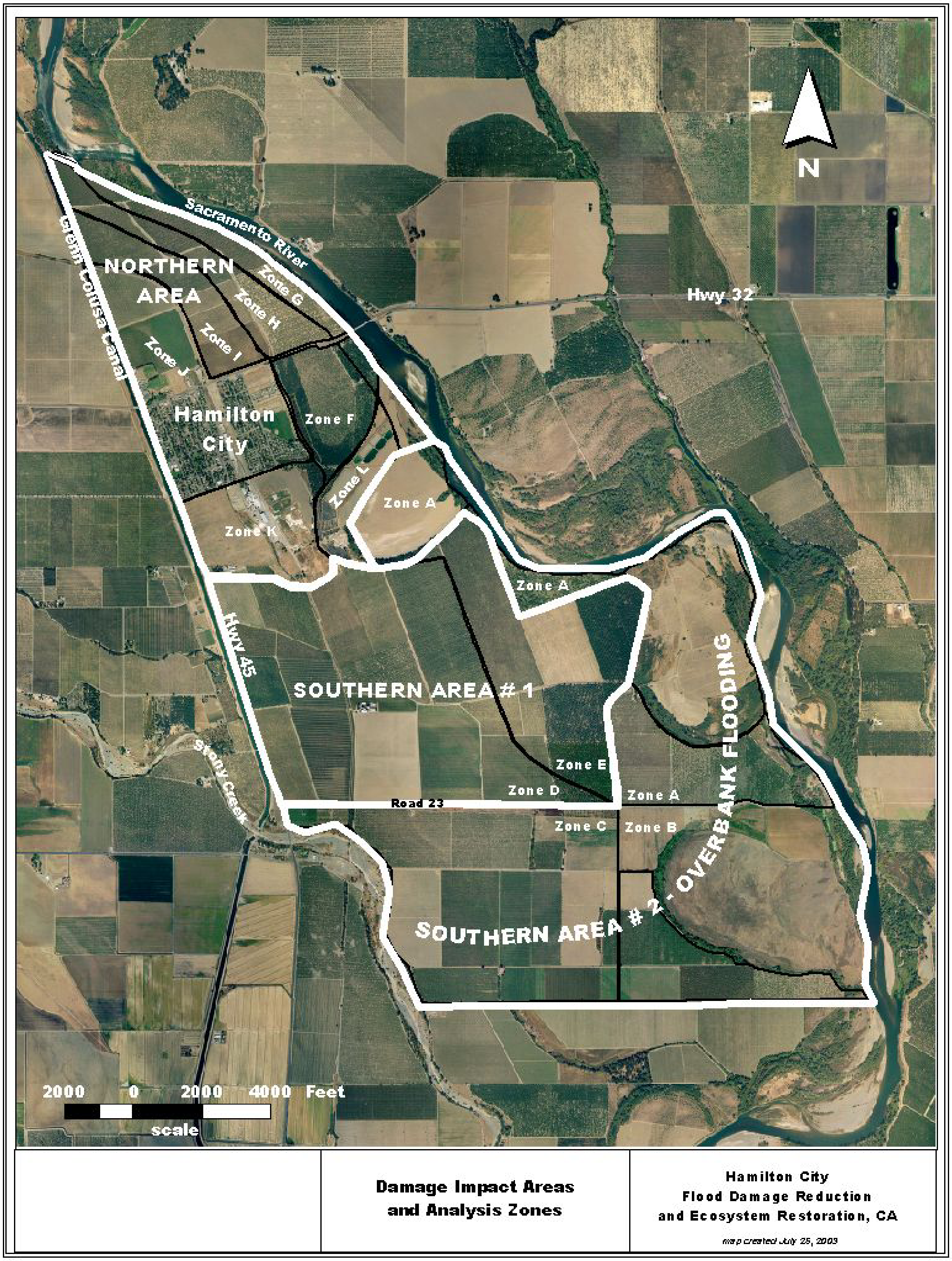


Table 1
Comparison of Technical Studies Models and Assumptions
2001 and 2003 Economic Analyses

Technical Study	Original Analysis (October 2001)	Revised Analysis (July 2003)
Hydrology & Hydraulics		
Model	HEC-RAS (steady state)	HEC-RAS (steady state)
Storm Centering Assumptions	Comp Study	Revised Comp Study to be more site specific
Levee Failure Assumptions		
In-Channel Flows	Left (east) bank—no levees	Left (east) bank—levees
	Right (west) bank—no levees	Right (west) bank—levees
Floodplain Delineations	Left (east) bank—no levees	Left (east) bank—levees
	Right (west) bank—no levees	Right (west) bank—no levees
Floodplain Maps	2%, 1%, 0.5%, 0.2% and 0.1% chance events	50%, 10%, 4%, 2%, 1%, 0.5%, 0.2% and 0.1% chance events
Index Points	River Mile 198.61 (1997 Comprehensive Study)	River Miles 198.25, 197.25 and 194.25 (1997 Comprehensive Study)
Backwater Flooding	Not analyzed	Analyzed
Geotechnical		
Levee Failure Assumptions	Top of levee, probable non-failure point, probable failure point identified at index points (TOL, PNP, PFP)	Top of levee, probable non-failure point, probable failure point identified at index points (TOL, PNP, PFP)
Economics		
Model	Hydrologic Engineering Center's Flood Damage Reduction Analysis (FDA)	Hydrologic Engineering Center's Flood Damage Reduction Analysis (FDA)
Impact Areas	Hamilton City (entire area)	Hamilton City (includes northern agricultural areas)
		Northern (Hamilton City and agricultural area to north)

Table 1
Comparison of Technical Studies Models and Assumptions
2001 and 2003 Economic Analyses

Technical Study	Original Analysis (October 2001)	Revised Analysis (July 2003)
		Southern #1 (southern agricultural area protected by "J" Levee)
		Southern #2 (southern agricultural area not protected by "J" Levee)
Analysis Zones	None	Impact areas divided into analysis zones to account for differences in areas protected by alternative setback levee alignments
FDA Adjustments (F3 to F4)	None	Add stage-damage curves for 10%, 4% chance events (2003 H&H)
		Translate frequencies from 2001 H&H to 2003 H&H for 2%, 1%, 0.5%, 0.2% chance events
		Translate stages from 2001 index point to 2003 Hamilton City index point (RM 198.61 to 198.25)
FDA Model Outputs	Expected Annual Damage Project Performance Statistics	Expected Annual Damage Project Performance Statistics

E.2 FLOOD DAMAGE REDUCTION ANALYSIS METHODS

A primary objective in flood damage reduction studies is to determine the expected annual damage (EAD) along a river reach taking into account all possible flood scenarios and to compare changes in the damage resulting from various alternative plans over the study period. Expected annual damage is approximately equivalent to an average annual damage estimate, taking into account all possible storm events that might occur, from very frequent to very infrequent. The determination of EAD in a flood management study must take into account interrelated hydrologic, hydraulic, geotechnical and economic information. Specifically, EAD is determined by combining the discharge-frequency, stage-discharge (or stage frequency), and stage-damage functions and integrating the resulting damage-frequency function. Stage refers to water surface elevation. Uncertainties are present for each of these functions and are carried forth into the EAD computation. In addition, for many studies (including the Hamilton City), most of the rivers have levees. Adding levees to channels keeps more flowing water from breaking out into adjacent land area. However, as the volume of water behind the levee rises, the probability of levee failure increases. Thus, the derivation of geotechnical levee probability of failure curves becomes very critical to the analysis. Once levees have failed and water enters the floodplain, then stages in the floodplain (which inundate structures and crops) become more critical to the EAD computation than stages in the river channel.

E.2.1 Risk Analysis

Risk involves exposure to a chance of injury or loss. The fact that risk inherently involves chance leads directly to a need to describe and plan for uncertainty. Corps policy has long been to acknowledge risk and uncertainty in anticipating floods and their impacts and to plan accordingly.[2] Historically that planning relied on analysis of the expected long-term performance of flood-damage reduction measures, application of safety factors and freeboard, designing for worse case scenarios, and other indirect solutions (such as engineering judgment) to compensate for uncertainty. These indirect approaches were necessary because of the lack of technical knowledge of the complex interaction of uncertainties in estimating hydrologic, hydraulic, geotechnical and economic factors due to the complexities of the mathematics required for doing otherwise. However, with advances in statistical hydrology and the availability of computerized analysis tools (such as HEC-FDA), it is now possible to improve the evaluation of uncertainties in the hydrologic, hydraulic, geotechnical and economic functions. Through this risk analysis, and with careful communication of the results, the public can be better informed about what to expect from flood-damage reduction projects and thus can make more informed decisions.

The determination of EAD for a flood reduction study must take into account complex and uncertain hydrologic, hydraulic, geotechnical, and economic information:

- **Hydrologic** - The discharge-frequency function describes the probability of floods equal to or greater than some discharge Q,
- **Hydraulics -** The stage-discharge function describes how high (stage) the

2 *In a flood damage reduction study, risk is defined is the probability of failure during a flood event. Uncertainty is the measure of the imprecision of knowledge of variables in a project plan.*

flow of water in a river channel might be for given volumes of flow discharge,

- **Geotechnical -** The geotechnical levee failure function describes the levee failure probabilities vs. stages in channel with resultant stages in the floodplain, and
- **Economics -** The stage-damage function describes the amount of damage that might occur given certain floodplain stages.

Figure 4 illustrates the conceptual risk approach for Corps' flood damage analyses. To find the damage for any given flood frequency, the discharge for that frequency is first located in the discharge-frequency panel (panel #1), then the river channel stage associated with that discharge value is determined in the stage-discharge panel (panel #2). As mentioned above, the study area contains the "J" Levee located along the west bank of the Sacramento River. Levees typically fail before the water reaches the top (panel #3).[3] Once levees have failed and water enters the floodplain, then stages (water depths) in the floodplain inundate structures and crops and cause damage (panel #4, left side).[4] By plotting this damage and repeating for process many times, the damage-frequency curve is determined (panel #4, right side).[5] EAD is then computed by finding the area under the flood damage-frequency curve by integration for both without and with-project conditions. Reductions in EAD attributable to projects are flood reduction benefits. Uncertainties are present for each of the functions discussed above and these are carried forth from one panel to the next, ultimately accumulating in the EAD. These uncertainties are shown in Figure 4 as "error bands" located above and below the hydrologic, hydraulic and economics curves.[6]

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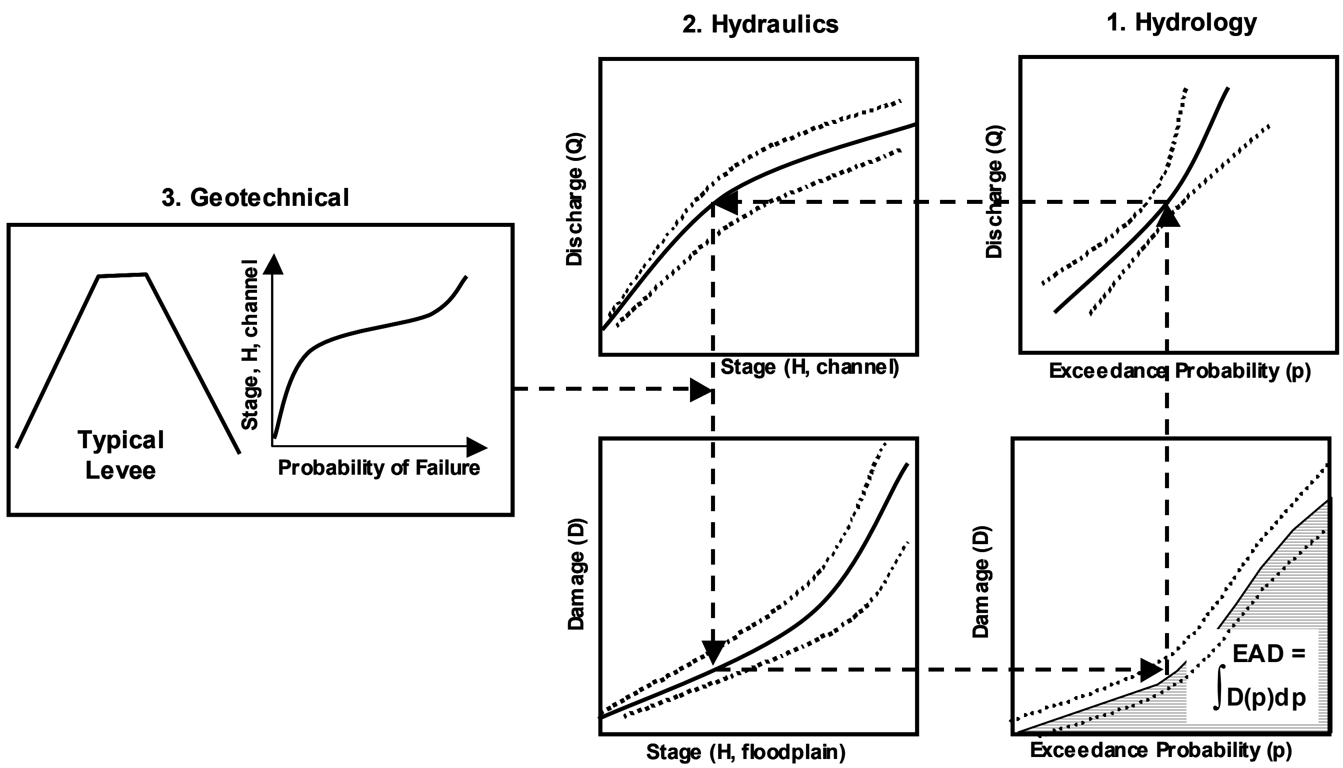
3 Project levees are levees that are part of a Federal flood control project. They include levees built by the Corps as well as levees built by others and brought up to the Corps design standards applicable at the time of incorporation into the federal project. The maintenance of project levees is usually the responsibility of the local sponsors. Non-project levees (such as the "J" Levee) are not part of a federal flood control project and are built and maintained by individuals and agencies other than the Corps.

4 For reaches without levees, the stage in the channel and overbank areas is used to determine damage.

5 The HEC-FDA model, described in section E.2.2, uses Monte Carlo analysis to repeat this "sampling" process thousands of times. Mathematically, FDA computes EAD in a different manner than illustrated by this figure.

6 Uncertainty in the geotechnical levee probability of failure curves are multitude in character and the resultant curve used in the analysis reflects how well that levee can be expected to perform during random periods of high flows for a particular reach length. Typically the greater the length of the levee reach, the less reliably that reach will perform during a flood event.

Figure 4
Conceptual Risk Approach for Estimating Flood Damage



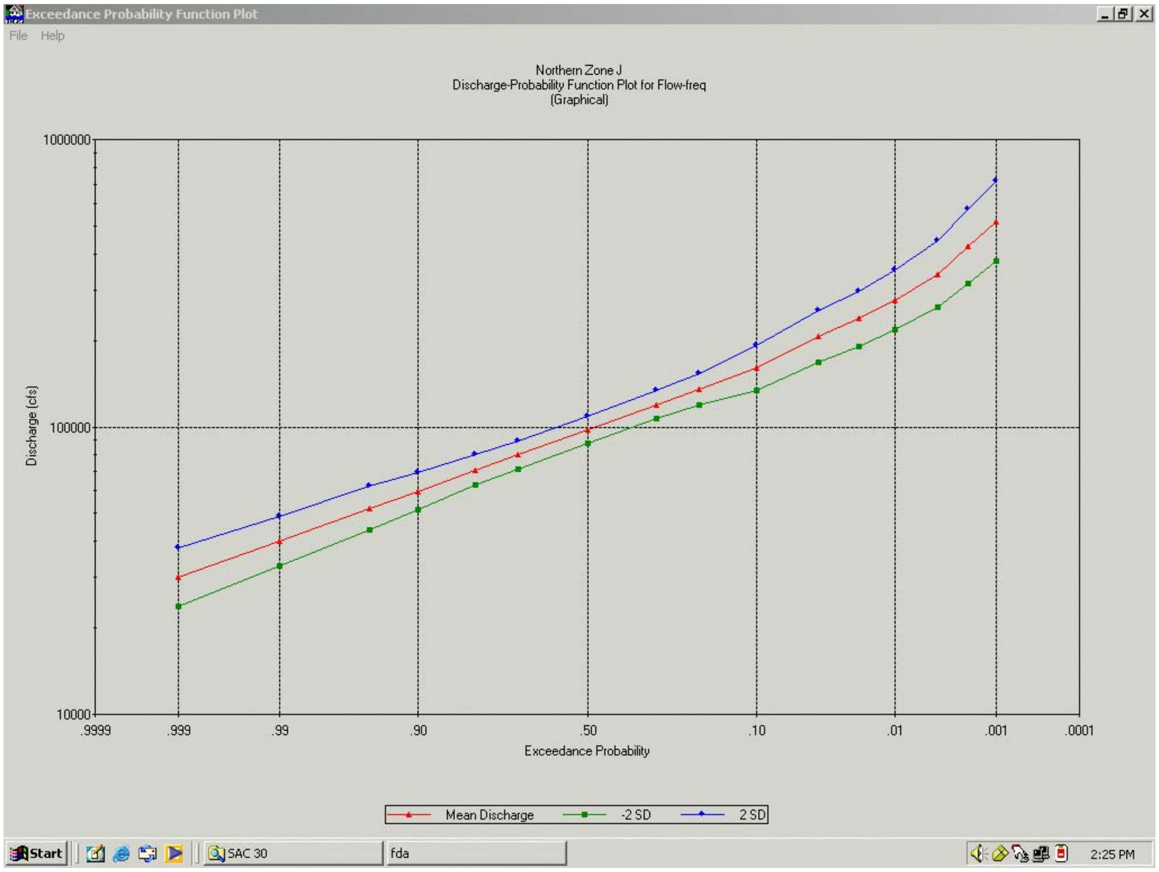
Source: Adapted from Moser (1997)

Some of the important uncertainties specific to the Hamilton City Flood Damage Reduction and Ecosystem Restoration Study include:

- **Hydrologic** - Uncertainty factors include hydrologic data record lengths that are often short or do not exist, precipitation-runoff computational methods that are not precisely known, and imprecise knowledge of the effectiveness of flow regulation.[7] Using the graphical method, FDA automatically assigned error bands based upon the input frequency-discharge curve and the hydrologic periods of record (80 years). The resulting curves are shown in

[7] *The hydrologic data record lengths (period of record) are the number of years of a systematic record of peak discharges at a stream gage. This parameter directly influences the uncertainty associated with the frequency-discharge function shown in Figure 5 and consequently the project performance statistics. In general, a longer period of record implies less uncertainty associated with this function. For the Hamilton City Study, the hydrologic period of record is 80 years.*

Figure 5
Frequency-Discharge Curve and Uncertainties
Sacramento River
River Mile 198.25

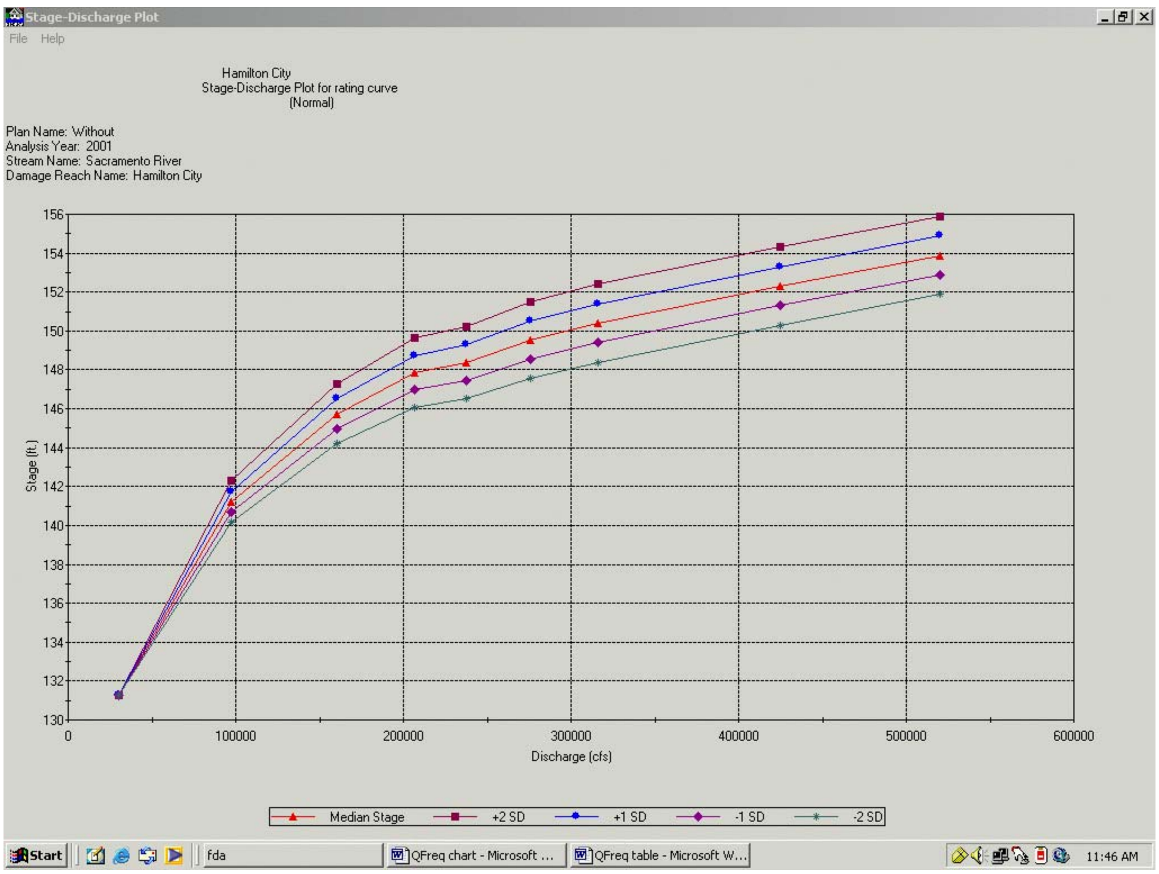


- **Hydraulics** - Uncertainty arising from the use of simplified models to describe complex hydraulic phenomena, including the lack of detailed geometric data, misalignments of hydraulic structures, material variability, and from errors in estimating slope and roughness factors. FDA automatically assigned error bands to the stage-discharge curve, as illustrated in Figure 6. FDA assigns these bands based upon an assumed error distribution (normal for this study) and constant errors above a calculated (or user specified) stage.
- **Geotechnical** - Uncertainty in the geotechnical performance of flood control structures during loading from random events such as flood flows and earthquakes affect levee performance. Other uncertainties may include geotechnical parameters such as soil and permeability values used in analysis, mathematical simplifications in the analysis models, frequency and magnitude of physical changes or failure events, and the uncertainty of unseen features such as rodent burrows, cracks within the levee, or other defects. Although geotechnical uncertainties are present, the current

version of FDA does not assign error bands around the levee failure curves.

- **Economics** - Uncertainty concerning land uses, depth/damage relationships, structure/content values, structure locations, first floor elevations, floodwater velocity, the amount of debris and mud, flood duration, and warning time and response of floodplain inhabitants. Specific uncertainties for key economic variables are presented below in the section, Stage-Damage Curves.

Figure 6
Stage-Discharge Curve and Uncertainties
Sacramento River
River Mile 198.25



E.2.2 HEC-FDA Model Development

The Hydrologic Engineering Center's Flood Damage Reduction Analysis (FDA) program was used to estimate equivalent annual damages. The program utilizes risk analysis to integrate hydrologic, hydraulic, and economic and geotechnical relationships. Engineering provided discharge-probability, stage-discharge, and levee failure curves that were combined with the frequency/stage-damage functions generated from the @RISK analysis described further below.

The development of the FDA files for the study area was complicated by (1) different types of flooding (overland vs backwater) and (2) several alternative levee setback alignments:

- **Types of flooding**: To the north of Hamilton City, the existing "J" Levee is subject to levee failure caused by high flows in the Sacramento River, as well as continuing erosion throughout the year. Levee failure in this area threatens croplands to the west of the levee as well as the town itself. Directly east of Hamilton City, the "J" Levee is very susceptible to failure, which would cause overland flooding of the town itself. Immediately south of town, the agricultural areas receive some protection from the "J" Levee, which extends south to County Road 23. However, this protection is limited to flows directly originating from the river to the east. These southern lands are still subject to backwater flooding, which creeps around the southern end of the "J" Levee. Further south of County Road 23, the agricultural lands are not protected by levees and they are consequently subject to frequent, and sometimes high-velocity, overland flooding from the river.
- **Alternatives**: In order to address these different types of flood threats (and to also address the ecosystem restoration objective of the project), different levee setbacks have been identified for the Northern, Central and Southern #2 impact areas. These setbacks can be "mixed and matched" from north to south resulting in numerous permutations of alternatives, which are described in more detail in Chapter 3 of the main report and the "With-project" section below.

Because of these complexities, the impact areas were further subdivided into analysis zones whose boundaries followed the alternative levee alignments. A separate FDA file was created for each analysis zone so that different plans (levee protection, buyout, etc.) could be analyzed. The analysis zones were shown in Figure 3.

E.3 WITHOUT-PROJECT CONDITIONS

A critical step in the economic analysis is the identification of the without-project conditions, which includes not only existing conditions, but also future without-project conditions expected to occur over the 50-year analysis period.

E.3.1 Floodplains

The primary risk (highest probability) of flooding to Hamilton City is from upstream unregulated tributary streams along the Sacramento River between Shasta Dam and Hamilton City. Runoff from these streams can cause the Sacramento River water level to rise and break through or overtop the "J" Levee. Extremely large storm events in the upper Sacramento River watershed result in high release flows from Shasta Dam, which could cause flooding in the Hamilton City area. Similarly, large storm events in the Stony Creek watershed can result in high release flows from Black Butte Dam, causing flooding in the Hamilton City area. In both cases, however, the probability of flooding due to dam releases is relatively low compared to the risk from the unregulated tributaries. The community relies on the "J" Levee to contain flows in the Sacramento River. The "J" Levee does not meet Corps or any other levee construction standards and could fail at river levels well below the top of the levee.

The Hamilton City study area is subject to both overbank and backwater flooding. Overbank flooding originates from the right (west) bank of the Sacramento River and directly threatens the existing "J" Levee and the community and farmlands landside of that levee. However, the southern end of the "J" Levee (near County Road 23) does not tie into high ground, therefore floodwater can creep around the end of the levee and flood lands to the north, although usually with reduced velocities. To perform the economic analysis, existing condition floodplain maps were generated that show both types of flooding problems in the study area.

- **Overbank Flooding**. Utilizing the 2003 hydrologic and hydraulic (H&H) information, floodplain maps were generated for the 50%, 10%, 4%, 2%, 1%, 0.5% and 0.2% chance events (Figures 7 and 8). As an example, a 50% event has a 1 in 2 probability of occurring in any given year. Key assumptions that were used to develop these floodplain maps include:
  - The "J" Levee is assumed to be ineffective (i.e., removed from the hydraulic model).
  - Across the Sacramento River, the Butte County levees are assumed not to fail until they are overtopped.
- **Backwater Flooding**. Backwater flooding occurs when floodwater creeps around the southern end of the "J" Levee and fills in low-lying lands to the north (primarily analysis zone E and the eastern portion of analysis zone D). However, backwater flooding can reach as far north as the southern edge of Dunning Slough (analysis zone A). Backwater flooding typically occurs more frequently than flooding from levee failures, and it usually does not occur with the higher flood velocities associated with levee failure flooding (which can flow quickly through narrow breaks in levees), so damage tends to be less. Figure 9 shows the estimated backwater floodplains from water flowing around the southern end of the existing "J" Levee. If the "J" Levee were to be extended further south (as in some of the alternatives), backwater flooding would still be present although the floodplains would shift southward. Figure 10 illustrates the differences in levee failure vs. backwater flooding. Areas subject to levee failure flooding include I and II, with water originating from the river breaching the "J" Levee. In contrast, backwater flooding flows around the southern edge of the "J" Levee (through area III) and up into area II. Total flood damage should then be computed for areas I + II + III. But, these cannot be simply added together. Using Figure 10 as an example, adding damage in areas flooded by levee failures (I and II) to areas flooded by backwater flooding (II and III) double the counts of damage occurring in area II.

  Another complication is that the extents of the two types of floodplains (levee failure and backwater) may not always match (for example, as shown in Figure 10). Sometimes the extent of the backwater flooding may occur entirely within the extent of the levee failure floodplain, sometimes just the opposite, or they may overlap unevenly. To avoid expending significant amounts of time and resources studying the backwater flooding issue, a simplifying assumption was made that one of the floodplains (levee failure or backwater) is always contained within the other. Given this assumption, damage estimates from the levee failure and backwater flooding scenarios were computed separately using FDA, and the larger estimate of the two was taken as the damage estimate for that analysis zone. @RISK frequency/stage-damage curves and FDA files were developed separately for backwater and levee failure floodplains within an analysis zone.

Figure 7
Hamilton City Economic Analysis Floodplains

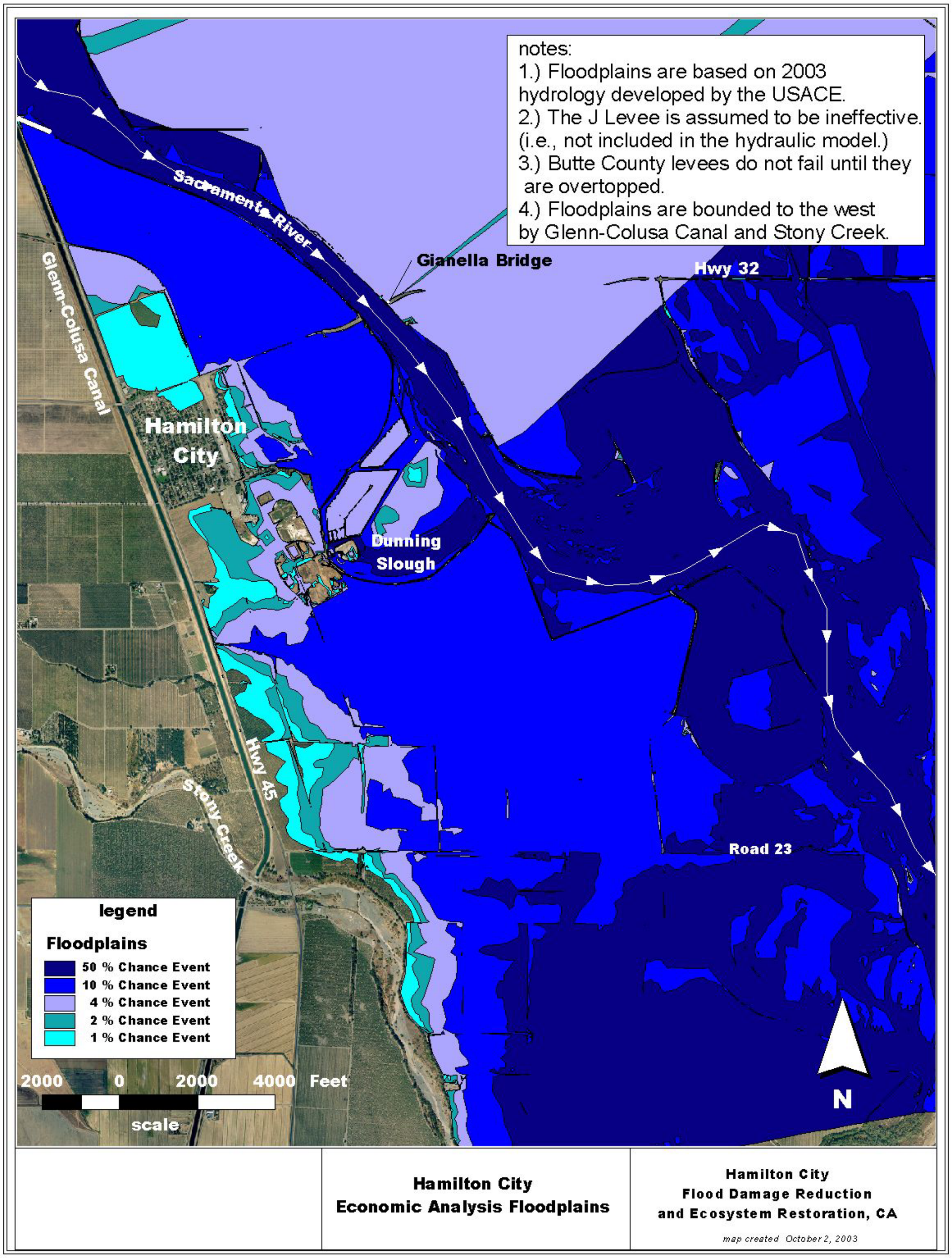


Figure 8
Hamilton City Economic Analysis Floodplains

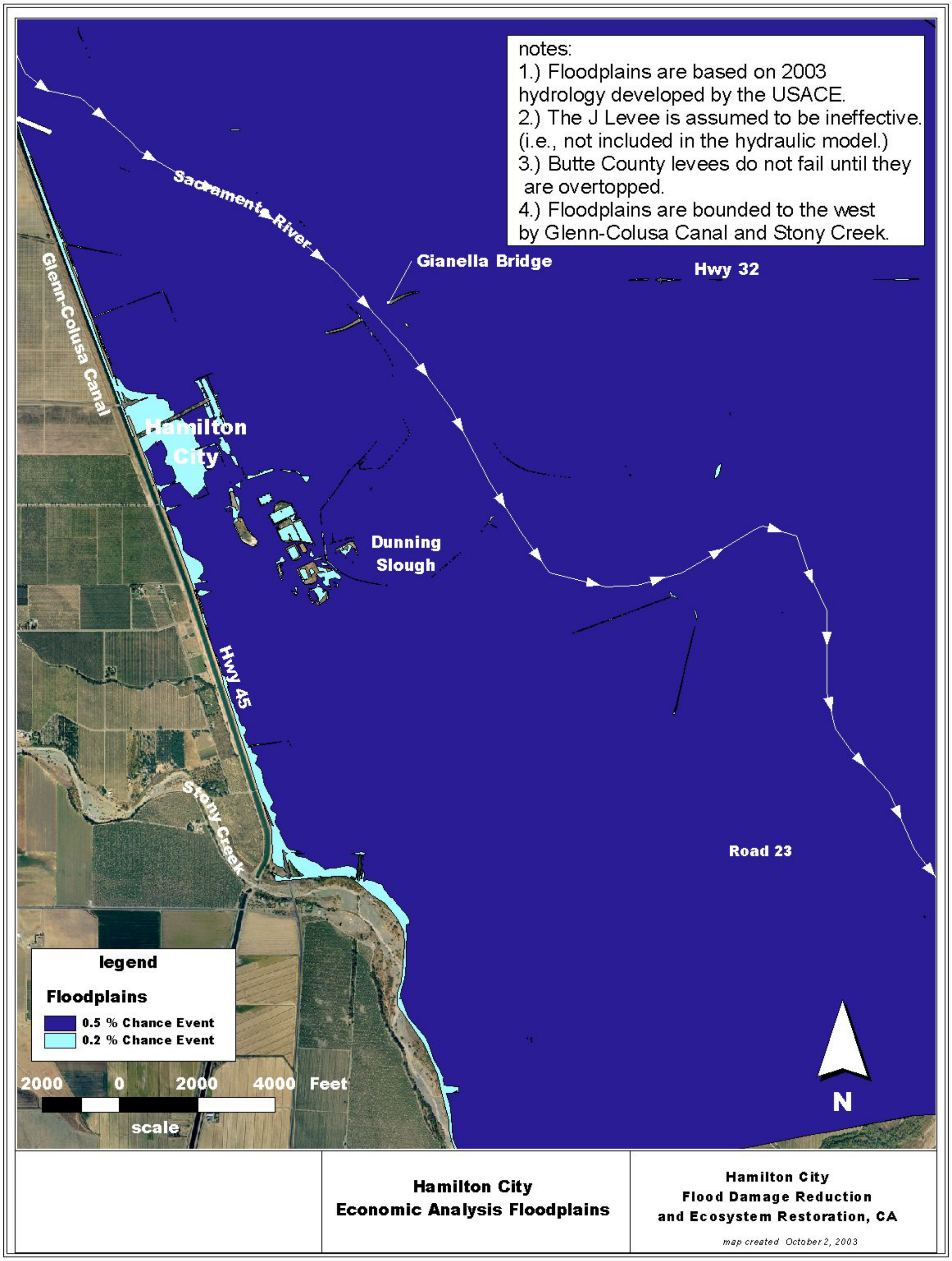
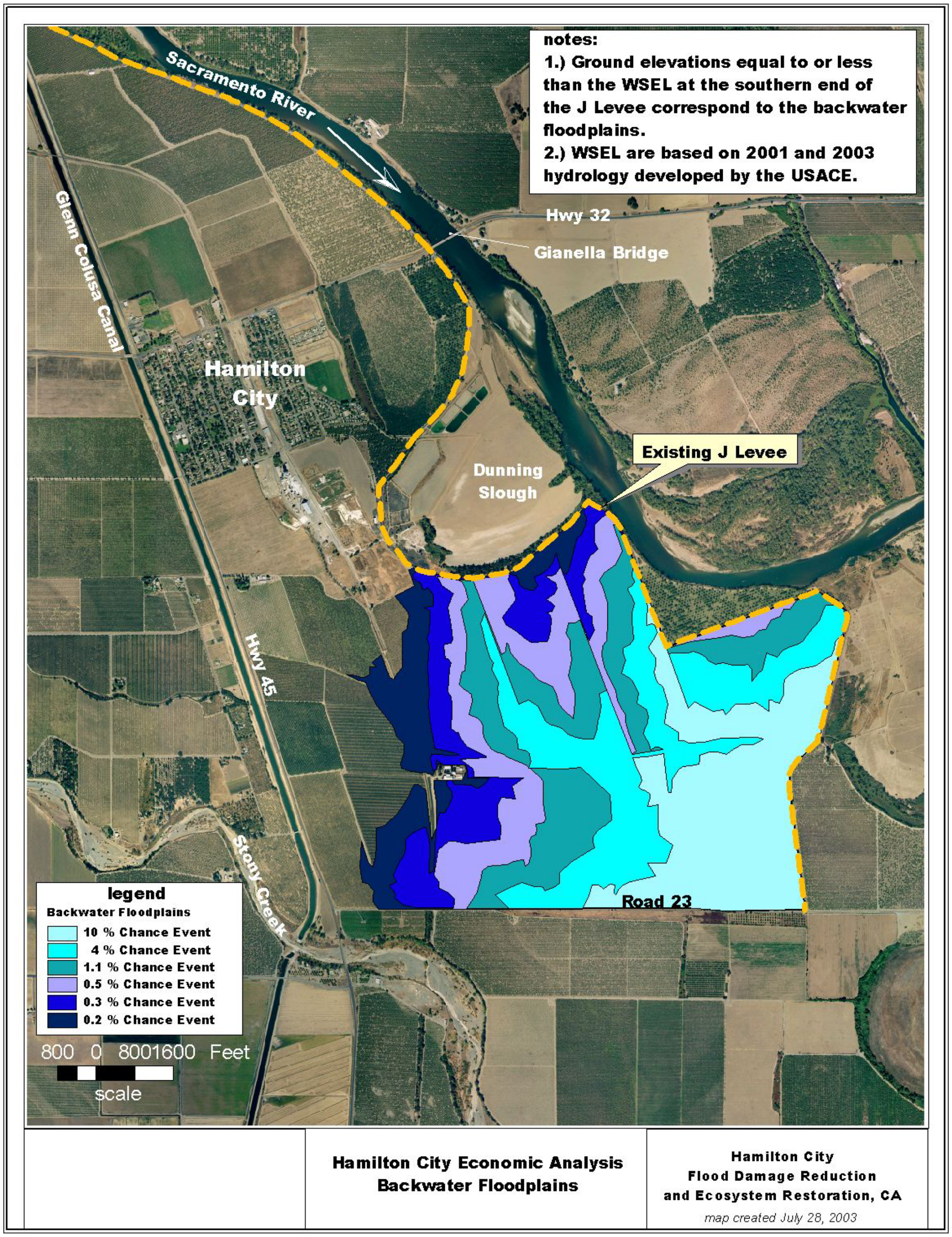
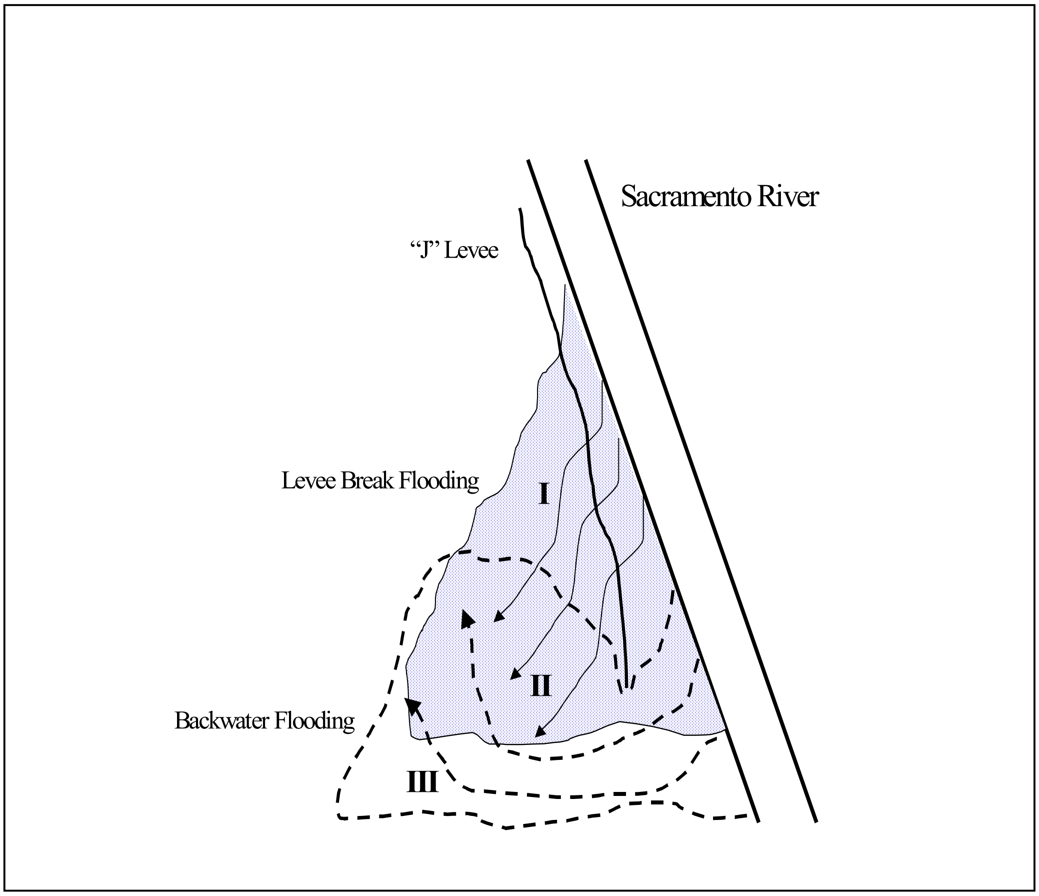


Figure 9
Hamilton City Economic Analysis
Backwater Flooding
(Without Project)



Note—This figure only shows backwater flooding flowing north from the southern end of the "J" Levee. Flows contributing to this backwater flooding (south of the "J" Levee) are not shown.

Figure 10
Levee Break Flooding vs. Backwater Flooding



Changes in future hydrologic and hydraulic conditions could affect the floodplains and thus the flood damage analysis; however, these changes have not been modeled (nor are there plans to do so because such an analysis would be highly speculative and could significantly affect the study schedule and cost). However, it should be remembered that hydrologic, hydraulic and geomorphic processes along the river do not remain constant over time, and changes in any of these factors (such as sedimentation) could potentially affect future flood damage.

E.3.2 Damage Categories

For analysis purposes, potential flood damage was classified into different categories:

- **Residential** – includes single family and multi-family units, houses, apartments, duplexes, mobile and manufactured homes. Damage includes physical damage to the structure, clean-up, damage to contents including household items and personal property, and clean-up.
- **Commercial** – includes retail stores, restaurants, service stations and light-repair garages. Damage was computed for both structure and contents including equipment, furniture, supplies and merchandise.
- **Public** – includes schools, churches, libraries and government service buildings such as the fire station and post office. Also included are the wastewater treatment ponds located in economic analysis zone L. Damage is comprised of losses to the building and its contents.
- **Agricultural/Industrial** – this category includes the agricultural production facilities, distribution and storage structures, including warehouses and processing plants. Damage was estimated for structures, equipment and inventories. Because many of the facilities are currently idle, including the largest processing plant in the area, content damages were limited to active units.
- **Emergency Costs** – additional costs incurred during flood emergencies for evacuation, temporary housing, medical supplies, food, clothing and re-occupation. Estimates were based on the number of people displaced, number of days evacuated or occupying temporary housing, and average daily costs (based on averages from other area flood studies.)
- **Auto** – damage to trucks and automobiles. Damages were determined as a percentage loss based on depth of flooding. Most vehicles begin to take measurable damages once water exceeds one-foot in depth.
- **Roads** – damage in the form of clean up, increased maintenance and repair. Estimates were a function of road miles inundated and average depth of flooding for the area surrounding the road.
- **Crop Damage** – includes the loss of cumulative cultivation costs incurred prior to flooding, the current net value of the crop affected by the flood event, the depreciated value of perennial crops lost as a direct result of flooding, and clean up costs.

E.3.3 Structure Flood Damage

Glenn County parcel maps were compared with floodplain maps to identify structures subject to flooding.[8] The area subject to flooding can be seen in the floodplain maps (Figures 7 and 8). Assessor's data was gathered using a CD-based database for Glenn County, including land use, structure type, assessed improvement value, and physical features. Field inspections were performed to determine foundation heights and to verify database physical characteristics. Adjustments were made to include public structures and those parcels that had changed land use or were not found in the database.

- **Structure Inventory**. The number of parcels with structures and the number of units are displayed by land use in Table 2. Based on this analysis, there are about 618 structured parcels within the largest floodplain (0.2% event, 2001 H&H) and nearly 690 residential units (including mobile homes). The residential structures include the new 116 units of the Pallisades subdivision located in the eastern part of Hamilton City. In the 2001 analysis, these were considered as "future growth", but since almost 80 have been completed (with the remainder to be finished by summer of 2004) they are considered to be "existing conditions" for the 2003 analysis.

Table 2 - Structure Inventory (1)

Land Use Type	Number of Parcels	Number of Units
Residential – Single Family (2)	464	464
Residential- Multi-Family	17	91
Residential- Mobile Home	94	135
Commercial	19	19
Public/Semi-Public	15	15
Agricultural/Industrial	9	9
Total	618	733

(1) All of these parcels are located within the Northern impact area with the exception of one agricultural production parcel, which is located in the Southern #1 impact area.
(2) Includes Pallisades subdivision (116 units).

- **Value of Damageable Property**. Value of damageable property includes both structure and content values, but does not include land values or crop value improvements. All structural values were based on adjusted assessed improvement values to represent depreciated replacement values. The first adjustment was made to account for California's Proposition 13, which allows for assessed values to be capped at an annual increase of two percent. Assessed values were adjusted (actual factor ranged from 5% to 99% depending on the recording date and structure type) based on sales recorded date and then compared to increases found in Marshall & Swift Valuation Service (Marshall & Swift). The next adjustment was based upon a sample of structures and determining improvement value using the square foot method. Values per square foot were taken from Marshall & Swift. Square footage was

[8] *Floodplain maps were used to identify structures and crops that are subject to damage. They are not the same as FEMA or other regulatory floodplain maps.*

gathered from the database and depreciation was determined based on a visual field inspection. For the structure sample, values were determined as a function of square footage multiplied by dollars per square foot multiplied by percent of remaining life of the structure (100% minus percent depreciation.). This sample was then compared to the adjusted assessed values to see if they were reasonable and to estimate standard deviations used in the risk analysis, which is described below. This second adjustment was minor, with residential values increased by 4% and standard deviations from 10% to 15% of the mean structure value. Content values were estimated as a percentage of structure value. These percentages were determined based on land use and were taken from the 1992 Yuba River surveys conducted for the USACE Sacramento District.[9]

For residential and public, content percentages were set at fifty percent. Commercial contents values ranged from 50% to 130%. Agricultural industrial warehouses are typically set at 100%, however, several buildings in Hamilton City are currently vacant or without contents. For those structures that do not have current redevelopment plans, contents were set at zero. Table 3 displays values by land use category under existing conditions.

Table 3
Value of Damageable Property
Existing Conditions
(Millions of Dollars; October 2003 Price Levels)

Land Use Category	Structure Value	Content Value	Total Value of Damageable Property
Residential (1)	33	17	50
Commercial	2	2	4
Public/ Semi Public	8	3	10
Agricultural/Industrial	6	2	8
Total	48	24	72

(1) Includes Pallisades subdivision.

- **Structure/Contents Depth-Damage Curves**. For most structural damage categories, dollar damage increases as depth of flooding increases. To evaluate potential losses, structural and contents depth - damage curves were entered into the @RISK models described below. For residential structure and content damage, the generic depth-damage relationships developed by the Institute of Water Resources (IWR) were used, as found in Economic Guidance Memorandum (EGM 01-03). These relationships are particularly relevant to this study as the nearby 1997 Arboga/Yuba County surveys were part of data compiled for the IWR study. For the commercial, public and agricultural/industrial sectors, the curves were the same

9 *Foster Associates, "Property Valuation For Portions of The Yuba River City Floodplain," August 20, 1992.*

relationships used in Modesto Pilot Study of the Sacramento-San Joaquin Comprehensive Study. These curves were originally taken from the Tennessee Valley Authority and have been verified and utilized in many Sacramento District studies. Separate curves were used for one-story vs. two-story structures and contents. For commercial structures, "S-shaped" and "U-shaped" curves were used.[10] Automobile depth-damage curves came from the 1983 Soil Conservation Service study for the Lower Silver Creek Watershed. Residential and auto damage depth-damage curves are shown in Tables 4 and 5.

Table 4
IWR Residential Structural and Contents Depth-Damage Curves
(One Story Residence)

Depth (feet)	Structural Depth-Damage		Content Depth-Damage[1]	
	Mean of Damage	Standard Deviation of Damage	Mean of Damage	Standard Deviation of Damage
-2	0%	0%	0%	3.0%
-1	2.5%	2.7%	2.4%	2.1%
0	13,4%	2.0%	8.1%	1.5%
1	23.3%	1.6%	13.3%	1.2%
2	32.1%	1.6%	17.9%	1.2%
3	40.1%	1.8%	22.0%	1.4%
4	47.1%	1.9%	25.7%	1.5%
5	53.2%	2.0%	28.8%	1.6%
6	58.6%	2.1%	31.5%	1.6%
7	63.2%	2.2%	33.8%	1.7%
8	67.2%	2.3%	35.7%	1.8%
9	70.5%	2.4%	37.2%	1.9%
10	73.2%	2.7%	38.4%	2.1%
11	75.4%	3.0%	39.2%	2.3%
12	77.2%	3.3%	39.7%	2.6%
13	78.5%	3.7%	40.0%	2.9%
14	79.5%	4.1%	39.9%	3.2%
15	80.2%	4.5%	39.6%	3.5%
16	80.7%	4.9%	39.1%	3.8%

(1) Expressed as a percent of structural value.

10 *S- and U-shaped commercial depth-damage curves were developed to reflect differences in types of inventory and how merchandise is stored (close to the floor or raised on shelves or other furniture). The U-shaped curves have greater damages at the lower depths than the S shaped curves (one looks sort of like an upside down U and the other sort of like an S).*

Table 5
Automobile Depth-Damage Curve (1)

Flood Depth	Percent Car Damage	Comments
0 – 0.9	0	Water not inside car
1.00 – 1.16	12.5	Water in floor of car
1.17 – 1.59	20.8	Water in seats of car, transmission, differential
1.60 – 2.00	45.8	Water in engine compartment and electrical equipment
> 2.00	80	Water in dash board instruments

(1) Source: 1983 Soil Conservation Service Study, Lower Silver Creek Watershed

- **Stage-Damage Curves**. To calculate stage-damage curves with uncertainty, a program called @RISK by Palisade Corporation was used. @RISK is an add-on program for MS-EXCEL, which incorporates Monte Carlo Simulation. The model uses variables with probability distributions to account for uncertainty. Computationally, @RISK outputs are frequency-damage curves that are then manually converted into stage-damage curves for entry into FDA. Economic variables and their associated uncertainty used in the damage template include:
  - Structure value (10% coefficient of variation)[11]
  - Contents value (10% coefficient of variation)
  - Foundation height (0.6 foot standard error)
  - Percent damage (5% coefficient of variation)

  For the original 2001 analysis, stage-damage (with uncertainty) was estimated for the 2%, 1%, 0.5% and 0.2% chance events by damage category. These were then linked to the corresponding stages at the index point used in the rating curve (discharge/stage) at river mile 198.61 based on river miles developed for the Comprehensive Study's hydraulics models. However, there have been several significant changes that have affected the original stage-damage curves, including:

(11*) The coefficient of variation measures variability in relation to the mean and is used to compare the relative dispersion in another type of data. The coefficient is equal to the standard deviation divided by the mean, multiplied by 100 to produce a percentage.*

- Revised hydrologic and hydraulic modeling: The 2001 H&H modeling efforts were revised to reflect site-specific information as well as adding more event frequencies (50%, 10%, and 4%). This improves the economic analysis by establishing when significant damage begins. However, it also creates complications in using stage-damage curves developed using different H&H modeling outputs because specific events in the 2001 analysis may no longer be those same event frequencies in the 2003 analysis. For example, a 1 in 100 (1%) year event in the 2001 analysis is now considered to be a 1 in 192 year event (about 0.5%) based upon the 2003 H&H modeling runs. Other events are also affected as shown in Table 6. In general, most events are now considered to occur less frequently based upon the 2003 H&H modeling. This is handled within FDA by inputting the 2001 stage-damage curves, but also inputting the 2003 discharge/probability and discharge/stage relationships, which essentially reassigns the 2003 frequencies to the 2001 stage-damage curves. Because more frequent events were analyzed in the 2003 H&H (50%, 10% and 25% chance events), floodplains were developed for those events and new stage-damage estimates were developed and added to the existing stage-damage curves. The results are stage-damage curves that reflect new information for the more frequent events and reassigned probabilities for events greater than the 2% chance event (2001 H&H).

Table 6
Comparison of 2001 and 2003 Event Frequencies
Sacramento River

2001 H&H	2003 H&H
NA	50% (1 in 2)
NA	10% (1 in 10)
NA	4% (1 in 25)
2% (1 in 50)	1.1% (1 in 88)
1% (1 in 100)	0.5% (1 in 192)
0.5% (1 in 200)	0.3% (1 in 370)
0.2% (1 in 500)	0.2% (1 in 520)
0.1% (1 in 1000)	0.1% (1 in 900)

NA—not evaluated

- Revised impact areas and index points: With more information concerning flooding patterns in the study area, two additional impact areas (Southern #1 and Southern #2, see Figure 3) were added to the 2001 Hamilton City (now called Northern) impact area. This necessitated the identification of two new index points (river mile 197.25 and river mile 194.25) and the linking of stage-damage curves to those index points. Nearly all of the damage in these two new impact areas is agricultural. The crop stage-damage curves were developed using the 2001 floodplains (and reassigning probabilities for events greater than 2%) plus adding new stage-damage information for the 50%, 10% and 4% chance events. In addition to the new index points, the index point in the Northern impact area was moved downstream (from river mile 198.61 to river mile 198.25) to avoid problems with water surface elevations being unduly influenced by the close proximity of the Gianella Bridge at river mile 198.61. This necessitated yet another adjustment in the stage-damage curves for this impact area to translate stages from the 2001 index point to the new index point.

The revised stage-damage curves are shown in Tables 7, 8, and 9 for the three impact areas. These stage-damage curves represent the damage caused by overland flows originating from levee failures and/or bank over-topping. They do not reflect backwater flooding into the southern impact areas. Although not shown, a separate set of backwater flooding stage-damage curves were also developed.

Table 7
Northern Impact Area (1)
Stage - Damage Curves (Existing Conditions) (2)
(Thousands of Dollars; October 2003 Price Levels)

Stage (ft)	Exceedance Years H&H Study		Stage-Damage Curves ($1,000)									
	2001	2003	Residential	Commercial	Mobile Homes	Public	Autos	Roads	Emergency Costs	Ag Industrial	Crops	Total
145.73	-----	10	0	0	0	0	0	0	0	0	223	223
147.85	-----	25	663	70	9	143	27	9	115	0	464	1,358
149.08	50	88	3,188	277	292	1,165	531	116	433	198	528	6,525
150.26	100	192	5,034	681	577	1,519	759	189	617	405	581	10,158
151.12	200	370	12,052	1119	881	2,836	1,409	268	1,685	863	607	21,517
152.42	500	520	16,643	2,065	1,336	3,900	2,007	351	2,166	1,101	611	29,908

(1) Includes analysis zones F, G, H, I, J, K and L.
(2) These stage damage curves reflect damage caused by overland flows from the river caused either by levee failures or water over top of bank, but do not include backwater-flooding effects.

Table 8
Southern #1 Impact Area (1)
Stage - Damage Curves (Existing Conditions) (2)
(Thousands of Dollars; October 2003 Price Levels)

Stage (ft)	Exceedance Years H&H Study		Stage-Damage Curves ($1,000)									
	2001	2003	Residential	Commercial	Mobile Homes	Public	Autos	Roads	Emergency Costs	Ag Industrial	Crops	Total
143.18	-----	10	0	0	0	0	0	0	0	0	752	752
144.87	-----	25	0	0	0	0	0	1	0	0	879	880
146.69	50	88	0	0	0	0	0	21	0	186	978	1,185
147.48	100	192	0	0	0	0	0	28	0	481	1,012	1,521
148.17	200	370	0	0	0	0	0	34	0	584	1,018	1,635
149.32	500	520	0	0	0	0	0	34	0	704	1,018	1,755

(1) Includes analysis zones D and E.
(2) These stage damage curves reflect damage caused by overland flows from the river caused either by levee failures or water over top of bank, but do not include backwater-flooding effects.

Table 9
Southern #2 Impact Area (1)
Stage - Damage Curves (Existing Conditions) (2)
(Thousands of Dollars; October 2003 Price Levels)

Stage (ft)	Exceedance Years H&H Study		Stage-Damage Curves ($1,000)								
	2001	2003	Residential	Commercial	Mobile Homes	Public	Autos	Roads	Emergency Costs	Ag Industrial	Crops
132.34	-----	2	0	0	0	0	0	0	0	0	498
135.40	-----	10	0	0	0	0	0	0	0	0	819
136.98	-----	25	0	0	0	0	0	1	0	0	880
138.53	50	88	0	0	0	0	0	21	0	0	918
139.70	100	184	0	0	0	0	0	28	0	0	929
140.79	200	330	0	0	0	0	0	34	0	0	940
142.16	500	520	0	0	0	0	0	34	0	0	945

(1) Includes analysis zones A, B and C.
(2) These stage damage curves reflect damage caused by overland flows from the river caused either by levee failures or water over top of bank, but do not include backwater-flooding effects.

E.3.4 Crop Flood Damage

The current land use for the study area was obtained from 1998 California Department of Water Resource's county land use files. Because these files are in a Geographic Information System (GIS) format, they were used to summarize the agricultural land area inundated for each flood event. For analytical purposes, five crops were selected as being representative of all crops grown within the study area: plums, prunes, almonds and walnuts (fruit and nut crops) and wheat (field crop). These five crops comprise the majority of all the rural acreage within the study area.

Crop damage includes losses directly caused by the flooding of agricultural land. Crop damage can occur during every stage of plant development as well as during periods of land preparation prior to the actual planting of the crop. It includes reduction in yield and quality resulting from plantings delayed by early floods or partially destroyed by floods of short duration, and losses incurred in replanting crops completely or partially destroyed by flooding. Both the loss of original expenses incurred in raising such crops, and the loss of income, which would have been received from their sale, contribute to flood damage. This study only estimates damage that accrues directly to the farm producer, or farmer, and not to the secondary processors within the region. Crop damage information has been obtained from interviews with cooperative extension agents and farmers that have been conducted over the past several years.

For this study, agricultural damage due to flooding for each acre was computed by adding the following types of costs:

- **Loss of the cumulative production (variable) costs incurred prior to flooding**: Production costs are incurred periodically throughout the crop year and include field preparation, chemical and fertilizer application, hired labor, planting, weed and pest control, harvesting, etc. These costs are computed on a monthly basis to determine the cumulative amount of production costs that are expended (and thus lost).
- **Loss of the crop net income affected by the flood event**: Crop net income is determined by subtracting the direct production (variable) costs from gross income. Loss of crop net income is a significant part of agricultural damage.
- **Loss of perennial crop depreciated value as a direct result of flooding**: Damage caused by long-term duration flooding may result in permanent loss of perennial crops (for example, permanent reductions in crop yields). The damage to perennials susceptible to flooding is computed based upon the assumption that the crop stands are at various ages, ranging from year 1 throughout their economic useful life. Accordingly, damage caused by long-term duration flooding is computed based upon a stand that is at the mid-point of its economic useful life.
- **Cost of activities associated with land clean up and rehabilitation resulting from flooding**: Erosion and deposition of debris and sediment may be caused by floods of any duration or time of year. Additionally, drainage and irrigation ditches may become clogged with silt and debris. Clean up and rehabilitation of farm acreage is accounted for in the computation of agricultural flood damages.

A significant difference between the 2001 and the 2003 analysis is improved crop flood damage estimates. Agriculture is the major industry within the study area, particularly orchards that are considered a long-term investment. Historically, orchards have been planted and grown in the surrounding area and it is expected that the current land use will continue.

Tables 10 and 11 present estimated existing conditions of crop acres and annual gross crop income.

Table 10
Crop Acres
Existing Conditions

Crops	Northern	Southern #1	Southern #2	Total
Almonds	452	387	550	1,389
Prunes	195	68	423	686
Plums	0	804	149	953
Walnuts	192	401	267	863
Grain	0	0	90	90
Total	839	1,660	1,478	3,977

Source: CA Department of Water Resources, Glenn County land use survey.

Table 11
Gross Crop Income
Existing Conditions
(Thousands of Dollars; October 2003 Price Levels)

Crops	Northern	Southern #1 & #2	Total
Almonds	781	1,628	2,409
Prunes/Plums	325	2,043	2,368
Walnuts	301	1,048	1,349
Grain	0	19	19
Total	1,407	4,738	6,145

The season of the year that the flood occurs greatly impacts the amount of flood damage to a crop. If flooding occurs early, producers may be able to re-prepare the field, plant and realize a return on their efforts. Conversely, a flood of substantial proportion occurring at harvest time will most certainly result in complete loss for the entire year. The probability of a storm occurrence, and accompanying flood damage, in any particular month was provided by the hydrology staff for the study area and indicates the likelihood of a storm occurring for each month throughout the year. Multiplying the direct production costs and the value of crop at risk for each month times the monthly probability provides the probable damages expected if a flood event occurred in any particular month.

During the course of the study, it became apparent that landowners in the extreme southern part of the study area (Southern #2 impact area) were concerned about flood flows leaving the Sacramento River and flowing south through lands unprotected by the "J" Levee (in Figure 3, these flows originate in analysis zone A and flow south through analysis zones B and C). These flows occur frequently because there is no levee protection, and they can also occur with high velocities causing significant damage. Based upon information submitted by a major landowner in the area concerning the extent and magnitude of damage occurred during past events, the crop frequency-damage curves for these analysis zones were adjusted to reflect this type of flooding.[12]

E.3.5 Levee Failure Assumptions

A critical input into FDA is the levee failure assumptions, which typically include three points on a levee failure curve: the top of levee (or top of bank if no levee is present), the probable failure point (85% chance of failure at this water surface elevation), and the probable non-failure point (15% chance of failure at this water surface elevation). Table 12 shows the without-project "J" Levee failure curves for the three impact areas (Southern #2 does not have a levee) as well as the curve used in the 2001 analysis at RM 198.61. Although not used in FDA, levee toe information is also shown for informational purposes (except for the 2001 curve).

Table 12
"J" Levee Failure Curves
(Without-Project)

Levee Failure Curve	2001 H&H	2003 H&H		
	Hamilton City (RM 198.61)	Northern (RM 198.25)	Southern #1 (RM 197.25)	Southern #2 (RM 194.25)
TOL/TOB (1)	151.0	149.2	145.3	133.9
PFP (2)	149.0	146.8	144.3	-----
PNP (3)	144.0	144.3	140.8	-----
TOE (4)	-----	142.4	137.0	-----

(1) Top of levee/top of bank (Southern #2).
(2) Probable failure point (85% chance of failure).
(3) Probable non-failure point (15% chance of failure).
(4) Toe of levee.

[12] *Computationally, this adjustment was done by increasing the duration time of floodwaters upon the acres at risk from this type of flooding. Although in reality duration times may not be longer with this type of flooding, mathematically it yields a higher damage estimate that approximates a more involved procedure of individually adjusting frequency-damage curves for these affected acreages.*

E.3.6 Equivalent Annual Damages

Tables 2 and 3 show existing structural inventories and associated structural and contents values. Future development within the floodplain is limited based on many factors including available space and demand. For the 2001 and 2003 analyses, future growth is limited to those development project sites specifically planned or under current construction. In the 2001 analysis, this future growth was comprised of 116 single-family homes in the Pallisades sub-division and a middle school located just east of Sacramento Avenue and south of CA Highway 32. Many of the homes, which range from 1,100 to 1,500 square feet, have already been completed, with the remainder (about 40) to be completed in 2004. Thus, for this analysis, these homes are now considered as existing condition. However, the middle school is still considered to be future conditions since it most likely will not be completed until 2010. Existing crop acreages are shown in Table 10. Table 11 shows annual gross crop income. These were assumed to remain constant over the analysis period based upon historical trends in the study area.

FDA was run for a base year of 2001 and future year 2010 conditions. Equivalent annual damages were estimated in the program using a 50-year period of analysis, October 2003 price levels, and a discount rate of 5 5/8%. Equivalent annual damage is the damage value associated with the without-or-with-project condition over the analysis period considering changes in hydrology, hydraulics, and flood damage conditions in the study area. Expected annual damage is computed for each analysis year and discounted to present worth, which is then annualized to obtain the equivalent annual damage value. Rather than compute the expected annual damage for each year, it is computed for the base year and most likely future year (2001 and 2010, respectively, for Hamilton City). Values in between these two years are interpolated, and values in later years are assumed to be equal to the most likely future year. For the 2003 analysis, the only difference between the base year and most likely future year is the assumed construction of a middle school in Hamilton City.

Equivalent annual damage over the period of analysis is displayed for the without-project condition in Table 13. For comparison purposes, the EAD estimates developed from the 2001 analysis are also shown. As shown in Table 13, the current EAD estimates are considerably higher than the 2001 estimates. The primary reasons for this are:

- The size of the 2003 study area incorporates the area of analysis zones B and C (see Figure 3) which were not included in the 2001 analysis, and
- The 2003 analysis uses a more detailed analysis of crop flood damage than what was used in 2001

Table 13
Without-Project
Equivalent Annual Damage
(Values in $1,000, October 2003 Prices)

Damage Category	2003 Analysis				2001 Analysis
	Northern	Southern #1	Southern #2	Total	
Residential	215	-	-	215	*214*
Commercial	22	-	-	22	*23*
Public	69	-	-	69	*65*
Ag/Industrial	18	10	-	27	*22*
Roads	6	1	1	7	*11*
Autos	26	-	-	26	*27*
Emergency Costs	27	-	-	27	*27*
Crops	55	129	189	373	*22*
Total	438	140	190	768	*411*

Note: numbers may not add due to rounding

E.3.7 Project Performance

Table 14 presents the without-project (existing levee) project performance statistics for the three impact areas. The three indicators of project performance estimated by FDA include expected annual exceedance probability, long-term risk, and conditional non-exceedance probability.

- **Expected annual exceedance probability (AEP)**. Expected AEP is a key element in defining the performance of a plan. It is the probability that a specific capacity or target stage will be exceeded in a given year.[13] For example, in Table 14, the Northern impact area expected annual exceedance probability is estimated to be 0.116, indicating that there is about a 12 percent chance of a damaging flood event along that particular river reach in any given year. If levees are located along the river reach (which is the case for the Northern and Southern #1 impact areas), the chance of their failure is also taken into account. Table 14 shows that AEP values increase for the southern impact areas. The 2001 AEP values are also shown for comparison purposes.
- **Long-term risk**. Long-term risk is the probability of a target stage being exceeded during a specified period. FDA estimates long-term risk for 10-, 25- and 50- year periods. For example, for the Northern impact area, the long-term risk for a 25-year period is estimated to be 0.9542, indicating that there is about a 95 percent chance that there will be one or more events that exceed a specified target stage during that time frame. These values also increase for the southern impact areas due to less reliable levees (in Southern #1) or no levees at all (Southern #2).

[13] *Target stage is the maximum stage possible before any significant flood damage is incurred.*

Conditional non-exceedance probability. This is the probability that a specified event will be contained by a project. If levees are involved, this statistic includes both the chance of levee overtopping as well as the chance of failure at lower stages. For example, in the Northern impact area, the conditional non-exceedance probability is 0.024 for a 2% (i.e., 1 in 50-year) event. This indicates that there is about a 2 percent chance that the target stage will not be exceeded for that particular flood event. Thus, while the expected annual exceedance and long-term risk probabilities measure the susceptibility of areas to flooding, conditional non-exceedance probability measures their ability to survive specified flood events. FDA generates conditional non-exceedance probabilities for the 10%, 4%, 2%, 1%, 0.4%, and 0.2% events.

For long-time residents of Hamilton City, this 12 percent chance of flooding annually in the Northern impact area may seem exaggerated because the town has not suffered major flooding in the last 50 years or so, even though severe flood events have occurred (most recently in 1997). The reason the town has not flooded is because of floodfighting—significant local, state and federal resources are typically used to combat flood events in Hamilton City so that the levee has not failed. If these events were not flood fought, then the chance of failure would have been greater, as is indicated by the FDA AEP results. There is no established way of incorporating floodfighting into a FDA analysis because of the uncertainties of these efforts actually being successful. However, the Study Team has developed an approach to incorporate floodfighting into the analysis and the results of this analysis are presented below.[14]

The long-term risk and conditional non-exceedance statistics are also subject to the distortions caused by the inability to incorporate floodfighting into the analysis. The long-term risk statistics are probably exaggerated because the levee curve input into FDA does not account for human efforts to protect it, thus greater long-term risk probabilities of failure will be obtained. Conversely, the conditional non-exceedance values are probably under-estimated by unknown amounts due to the use of levee curves that do not reflect human efforts to protect the levee during storm events.

[14] *This is described in the draft paper "Incorporating Floodfighting Into the Hamilton City HEC-FDA Analysis" (July 2003) included in Appendix A.*

Table 14
Project Performance Statistics
Without-Project

Impact Area	Annual Exceedance Probability (Expected)	Long Term Risk (Years)			Conditional Non-Exceedance Probability by Events					
		10	25	50	10% (1 in 10 years)	4% (1 in 25 years)	2% (1 in 50 years)	1% (1 in 100 years)	0.40% (1 in 250 years)	0.20% (1 in 500 years)
Northern	0.1160 (12%)	0.7086 (71%)	0.9542 (95%)	0.9979 (100%)	0.4805 (48%)	0.0881 (9%)	0.0240 (2%)	0.0054 (0.5%)	0.0005 (0.05%)	0.0001 (0.01%)
Southern #1 (1)	0.1500 (15%)	0.8039 (80%)	0.9830 (98%)	0.9997 (100%)	0.3957 (40%)	0.0700 (7%)	0.0158 (6%)	0.0032 (0.3%)	0.0000 (0.0%)	0.0000 (0.0%)
Southern #2 (2)	0.2370 (24%)	0.9335 (93%)	0.9989 (100%)	1.0000 (100%)	0.0650 (7%)	0.0033 (0.3%)	0.0004 (0.04%)	0.0000 (0%)	0.0000 (0%)	0.0000 (0%)
2001 Analysis	0.1170 (12%)	0.7134 (71%)	0.9560 (96%)	0.9981 (100%)	0.5631 (56%)	0.2795 (28%)	0.1250 (13%)	0.0492 (5%)	0.0134 (1%)	0.0049 (0.5%)

(1) For Southern #1 impact area, these statistics reflect the risk only of levee failure/overtopping. The risk of backwater flooding is higher.
(2) For Southern #2, these statistics reflect the risk of overbank flooding because no levee is present.

E.3.8 FDA Floodfighting Adjustments

As mentioned above, floodfighting is a critical part of flood management within Hamilton City and it does affect the flood damage analysis. It was determined that floodfighting costs should be incorporated into the flood damage reduction analysis. Floodfighting costs would be very significant for the without and future-without-project conditions, but may also be present (although hopefully in lesser amounts) in the future with-project conditions. The comparison of floodfighting costs between the without and with-project conditions would be important for the flood damage reduction analysis.[15] However, to be consistent, these costs cannot be included until the flood damage analysis (using the FDA program) is also adjusted to reflect the benefits of floodfighting (i.e., reduced flood damage).

A proposed method for incorporating floodfighting into FDA is discussed in Appendix A: Plan Formulation. This method relies upon modifying the levee failure curves that are developed by geotechnical specialists and input into FDA. These curves typically have three points: the probable non-failure point (PNP), the probable failure point (PFP), and the top of levee (TOL). The PNP is the water surface elevation at which there is about a 15% chance of levee failure and the PFP is the water surface elevation with about an 85% chance of levee failure. These curves are based upon the physical characteristics of levees and they do not reflect any floodfighting actions taken to protect levees. Table 15 shows the "without floodfight" levee failure curves currently input into FDA for the Northern and Southern #1 impact areas. The Southern #2 impact area is not protected by the "J" Levee.

To adjust the FDA analysis for floodfighting requires that the levee failure curves be modified to reflect social actions taken to protect the levee (patrolling, sandbagging, plastic sheathing, boil repairs, etc.). These curves were adjusted as follows:

- **Northern Impact Area (Index Point River Mile 198.25)**: The maximum river stage at the Hamilton City gage (just upstream of the Gianella Bridge) in 1997 was 147.92 (National Geodetic Vertical Datum). This was the highest recorded stage in the past 20 years. The estimated stage at the Northern impact area index point for the 1997 event was 147.5. Thus, the without-project PFP of 146.8 should be changed to 147.5 since the levee seemed able to withstand this type of event—with floodfighting. The PNP was increased an equivalent distance (0.7 feet) from 144.3 to 145.0, since it is reasonable to assume floodfighting would be at least as effective at a lower river stage. In addition to raising the PNP and PFP values, it was also decided to add another point on the levee failure curve for input into FDA. This point was one-half foot less than the top of levee (148.70) and it was assigned a probability of failure of 0.99.
- **Southern #1 Impact Area (Index Point River Mile 197.25)**: The same logic

[15] It should be noted that even though the FDA model is being adjusted to account for it, floodfighting is not really a reliable flood management strategy. The "J" Levee did not perform well in 1986 and 1998, and the inhabitants of Hamilton City narrowly escaped disaster. People were displaced temporarily. What were left were a scoured/eroded levee with thousands of sand bags and visqueen holding the remains of the levee together.

was followed as within the Northern impact area, except the PFP and PNPs were only be increased by half the amount (about 0.3 feet) to reflect to reflect that floodfighting for the potential mode of levee failure for these levees is problematic. The additional point (0.99 probability of failure) was added about one-quarter of a foot less than the top of levee.

These curves are for *existing conditions*. Continued deterioration of the "J" Levee can be expected over time, which would ideally be accounted for by lowering the PFP and PNPs (without and with floodfighting). Within FDA, this adjustment would occur by inputting these "deteriorated" levee curves at some future year (say 2030). Unfortunately, FDA does not allow for analysis years to be changed once they have been entered, thus this adjustment cannot be made. As a consequence, increases in future flood damage caused by the use of "deteriorated" levee failure curves will not be included in the flood damage reduction analysis.

FDA was run again incorporating the without-project, floodfight-revised, levee failure curves. The results of these runs are shown in Tables 16 (equivalent annual damage) and 17 (project performance statistics). The without-project equivalent annual damage was reduced from $768,000 (Table 13) to $726,000 for the entire study area. This implies that floodfighting efforts on the "J" Levee reduce annual flood damage by about $42,000. The equivalent annual damage and project performance statistics shown in Tables 16 and 17 will be considered the "without-project" conditions which will be compared to "with-project" conditions (discussed below).

Table 15
Northern and Southern #1 Levee Failure Curves
Without and With Floodfighting

Levee Failure Curve	Northern		Southern #1	
	Without Floodfight	With Floodfight	Without Floodfight	With Floodfight
Top of Levee (TOL)	149.2	149.2	145.3	145.3
Additional point (0.99 probable failure)	-----	148.7	-----	145.1
Probable Failure Point (PFP)	146.8	147.5	144.3	144.6
Probable Non-Failure Point (PNP)	144.3	145.0	140.8	141.1
Toe of Levee	142.4	142.2	137.0	137.0

Table 16
Without-Project
With Floodfighting
Equivalent Annual Damage
(Values in $1,000, October 2003 Prices)

Damage Category	2003 Analysis				2001 Analysis
	Northern	Southern #1	Southern #2	Total	
Residential	210	-	-	211	*214*
Commercial	21	-	-	21	*23*
Public	54	-	-	54	*65*
Ag/Industrial	18	10	-	27	*22*
Roads	6	1	1	7	*11*
Autos	26	-	-	26	*27*
Emergency Costs	26	-	-	26	*27*
Crops	45	119	189	353	*22*
Total	406	130	189	726	*411*

At first glance, the equivalent annual flood damage estimate of $726,000 presented in Table 16 for the study area may not seem to correspond with historical flood damaging events, especially for the community of Hamilton City (Northern impact area). As pointed out in Section E.1.1, there has been only one occasion (1974) of flood damage within the community of Hamilton City, causing about $55,000 in damage plus $22,000 in levee repair costs. No other significant flood damage has occurred within the community, although there has been more frequent agricultural damage in the southern agricultural lands caused by backwater flooding and overland flows from the Sacramento River. The primary reason for the avoidance of significant flood damage in the community itself has been the reliance upon significant floodfighting efforts, which occurred in 1983, 1986, 1995, 1997, and 1998. Although floodfighting has so far proved relatively effective in avoiding significant flood damage[16], continual deterioration of the "J" Levee makes it much more unlikely that floodfighting will reliably protect the community of Hamilton City in the future.

Floodfighting is expensive, and unfortunately, good records of expenses for flood events are not available. However, based upon available historical information in the study area, future floodfighting costs have been estimated based upon three weather condition scenarios in the study area over the 50-year planning period: mostly dry years, average weather conditions, and mostly wet years. These costs are summarized in Table 18 and described in more detail in Appendix A: Plan Formulation.

[16] *Even with floodfighting, the community did not go completely unscathed by flood events. The residents were often temporarily displaced, and after each event the levee was left in a further degraded condition, with thousands of sand bags and visqueen holding the remains of the levee together. Significant federal, state and local resources were employed in the floodfighting efforts.*

Table 17
Northern and Southern #1 Impact Areas Project Performance Statistics
Floodfighting vs. No Floodfighting
Without Project

Impact Area	Annual Exceedance Probability (Expected)	Long Term Risk (Years)			Conditional Non-Exceedance Probability by Events					
		10	25	50	10% (1 in 10 years)	4% (1 in 25 years)	2% (1 in 50 years)	1% (1 in 100 years)	0.40% (1 in 250 years)	0.20% (1 in 500 years)
Northern (No Floodfighting)	0.1160 (12%)	0.7086 (71%)	0.9542 (95%)	0.9979 (100%)	0.4805 (48%)	0.0881 (9%)	0.0240 (2%)	0.0054 (0.5%)	0.0005 (0.05%)	0.0001 (0.01%)
Northern (With Floodfighting)	0.0860 (9%)	0.5929 (59%)	0.8942 (89%)	0.9888 (99%)	0.6628 (66%)	0.2157 (22%)	0.0956 (10%)	0.0349 (3%)	0.0057 (0.5%)	0.0006 (0.06%)
Southern #1 (No Floodfighting)	0.1500 (15%)	0.8039 (80%)	0.9830 (98%)	0.9997 (100%)	0.3957 (40%)	0.0700 (7%)	0.0158 (2%)	0.0032 (0.3%)	0.0000 (0.0%)	0.0000 (0.0%)
Southern #1 (With Floodfighting)	0.1310 (13%)	0.7548 (75%)	0.9702 (97%)	0.9991 (100%)	0.4643 (46%)	0.1317 (13%)	0.0447 (4%)	0.0117 (1%)	0.0025 (0.3%)	0.0002 (0.02%)

Table 18
Estimated Floodfight Costs (1)

Floodfight Activity	Mostly Dry Years		Average Weather		Mostly Wet Years	
	# of Events	Cost	# of Events	Cost	# of Events	Cost
Rock Revetment Floodfights	3	$3,000,000	4	$4,000,000	6	$6,000,000
Events with Floodfight Crews	6	$360,000	13	$780,000	20	$1,200,000
Associated Floodfighting Costs	-----	$450,000	-----	$975,000	-----	$1,500,000
Environmental Mitigation	-----	$360,000	-----	$530,000	-----	$800,000
Total Costs	-----	$4,170,000	-----	$6,285,000	-----	$9,500,000
Annualized Costs (2)	-----	$73,100	-----	$114,200	-----	$153,900

(1) Source: Appendix A: Plan Formulation
(2) Over 50 years; 5 5/8 interest rate.

Not surprisingly, regardless of the assumptions concerning weather conditions, all of the annualized floodfighting costs exceed the estimated annual damage reduced from floodfight activities (about $42,000).

E.4 WITH-PROJECT CONDITIONS

The objectives of the Hamilton City project are to improve ecosystem conditions along the Sacramento River and to reduce flood damage in the community of Hamilton City and surrounding agricultural areas. The benefits and costs of any proposed projects are determined by comparing "without project" vs. estimated "with-project" conditions.

E.4.1 Description of Alternatives

For the Hamilton City study area, several flood damage reduction and ecosystem restoration management measures were investigated and preliminary combined alternatives were identified which are summarized below. More detailed information can be found in Chapter 3 of the feasibility report.

- **No Action Alternative**: The Corps is required to consider the option of "No Action" as one of the alternatives in order to comply with the requirements of the National Environmental Policy Act (NEPA). With the No Action plan, which is synonymous with the "Without-Project Condition," it is assumed that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives. The No Action Alternative provides a base against which all other alternatives are measured and ensures that any action taken is more in the public interest than doing nothing.
- **Alternative #1**: Alternative 1 consists of constructing a levee about 6.6 miles long and about 6 feet high, set back roughly 500 to 7,600 feet from the river, and removal of most of the existing "J" levee. The alignment continues south of County Road 23 for about a mile as a training levee because it does not tie into high ground. Alternative 1 is shown in Figure 11.
- **Alternative #2**: Alternative 2 consists of constructing a setback levee about 3.8 miles long and setback roughly 1,300 to 2,700 feet from the river, breaching the existing "J" levee in several locations, and actively restoring about 1,400 acres of native habitat. Alternative 2 is shown in Figure 12.
- **Alternative #3**: Alternative 3 consists of This alternative consists of constructing a setback levee about 3.3 miles long and setback roughly 1,300 to 2,700 feet from the river, breaching the existing "J" levee in several locations, and actively restoring about 1,600 acres of native habitat. Alternative 3 is shown in Figure 13.
- **Alternative #4**: Alternative 4 consists of constructing a levee about 4.1 miles long, about 6 feet high, set back roughly 500 to 2,700 feet from the river, removing most of the existing "J" levee, and actively restoring about 1,100 acres of native habitat. Alternative 4 is shown in Figure 14.
- **Alternative #5**. Alternative 5 consists of This alternative plan consists of actively restoring about 1,600 acres of native vegetation, constructing a setback levee about 5.3 miles long, and about 6 feet high, and removing most of the existing "J" levee. The alignment continues south of County Road 23 for about a mile as a training levee because it does not tie into high ground. Alternative 5 is shown in

Figure 15.

- **Alternative #6.** Alternative 6 consists of actively restoring about 1,500 acres of native vegetation, constructing a setback levee about 5.7 miles long, and about 6 feet high, and removal of most of the existing "J" levee. The alignment continues south of County Road 23 for about a mile as a training levee because it does not tie into high ground. Alternative 6 is shown in Figure 16.
- **Alternative #7**: Alternative 7 does not include a setback levee and thus does not provide flood damage reduction benefits. All project lands, approximately 1,600 acres, would be restored but the "J" Levee would not be breached. Several of the areas to be restored would be located behind the existing J levee and would not be hydrologically connected to the river. Because of this, the value of the habitat in this alternative would be significantly lower in these areas because they are disconnected from the river and are not periodically subjected to flooding. Alternative 7 is shown in Figure 17.

Depending upon the alternative setback levee locations, individual analysis zones could be (i) located on the landside of the levee, thus lands would receive protection from it; (ii) located on the waterside of the levee, thus lands would be restored for ecosystem purposes; (iii) located to the south of the levee and may incur additional flooding, resulting in the need for flood easements to be purchased; or (iv) in some instances, not be affected by an alternative. Understanding how the analysis zones are affected by particular levee alignments was crucial for the FDA analysis.

Table 19 summarizes how the alternatives affect the different analysis zones. The alternative levee setback alignments and areas protected, restored etc. are shown in Figures 11 – 17.

Table 19
Summary of Plans and Effects Upon Analysis Zones

Plan	No Change	Zones with Additional Protection (1)	Zones Restored	Zones with Easements
No Action	A – L	None	None	None
Alternative 1	None	C,D,F,H,I,J,K,L	A,B,E,G	None
Alternative 2	B,C,L	I,J,K	A,E,F,G,H	D
Alternative 3	B,C,L	J	A,E,F,G,H,I	D,K
Alternative 4	B,C	F,H,I,J,K,L	A,E,G	D
Alternative 5	L	D,I,J,K	A,B,E,F,G,H	None
Alternative 6	None	C,D,F,I,J,K,L	A,B,E,G,H	None
Alternative 7	B,C,D,J,K	None	A,E,F,G,H,I	None

(1) Analysis zones C & D still subject to some backwater flooding.

Figure 11
Alternative 1

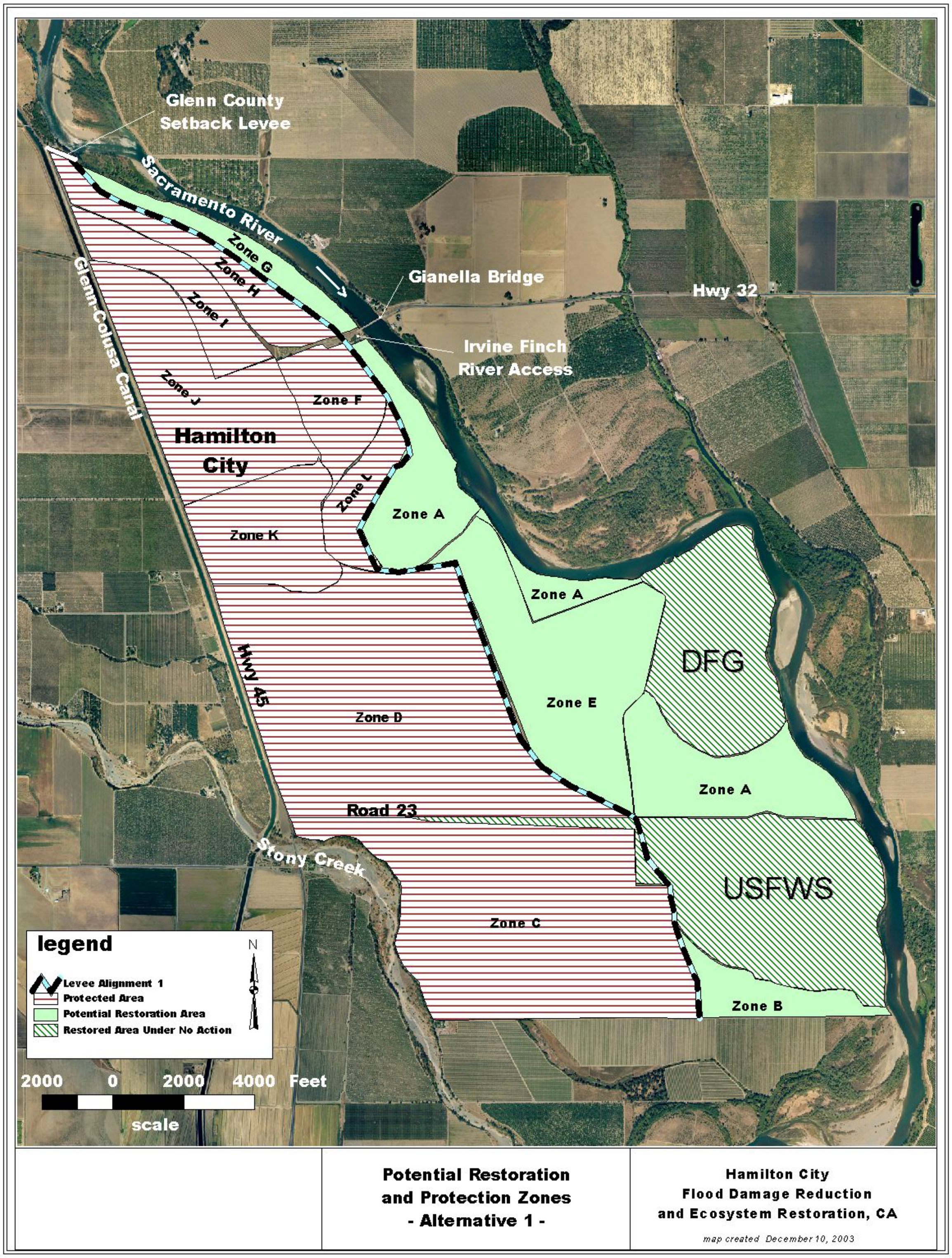


Figure 12
Alternative 2

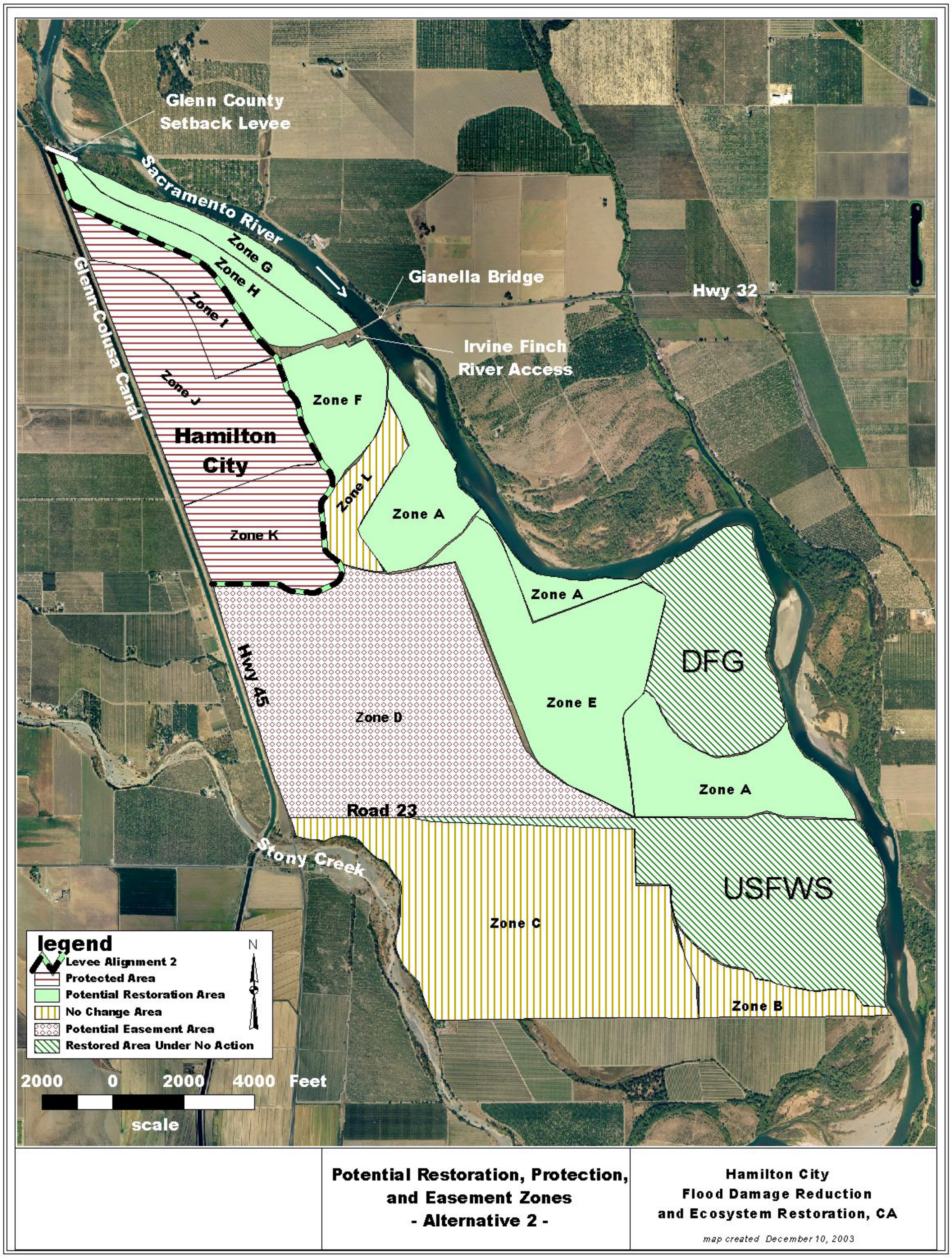


Figure 13
Alternative 3

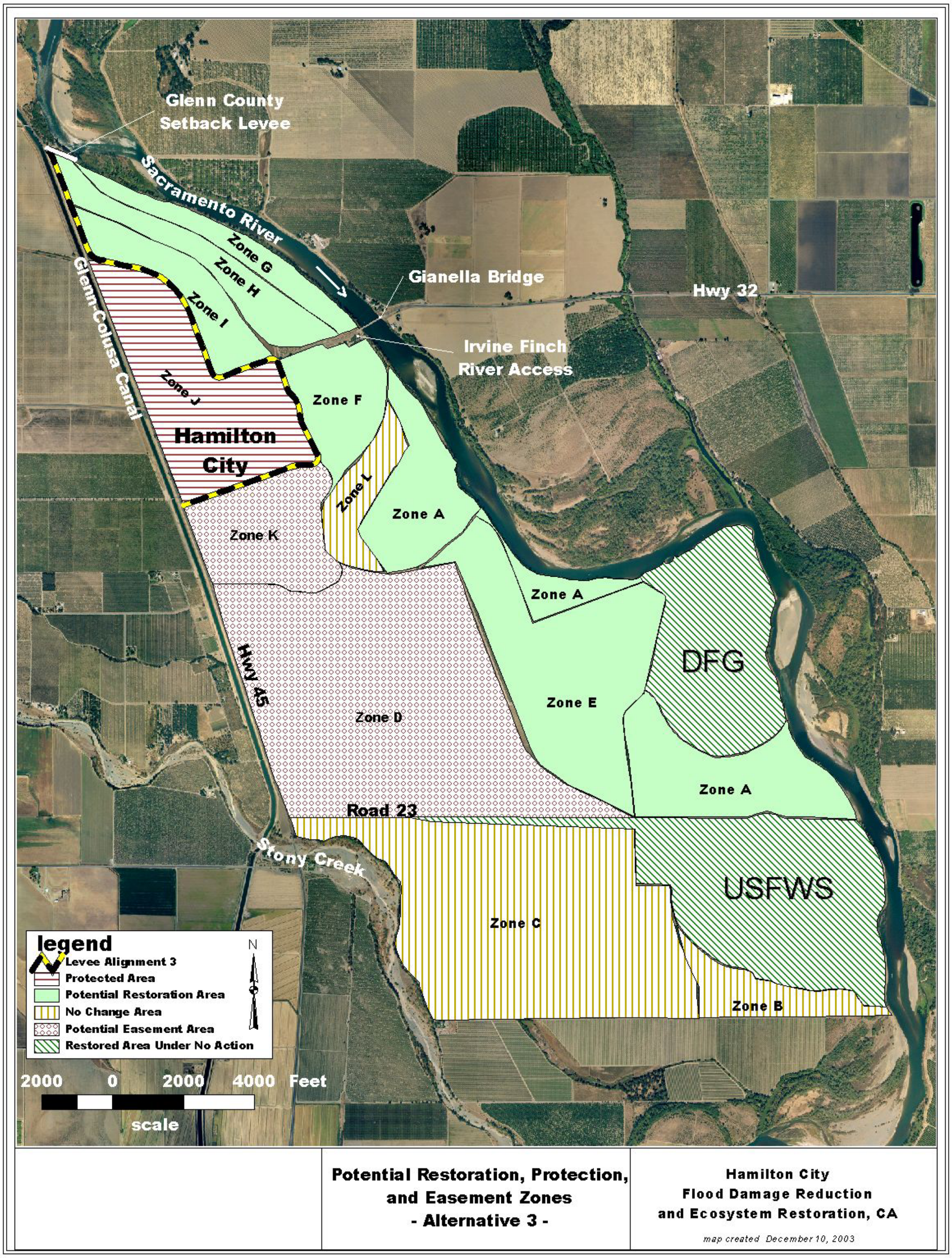


Figure 14
Alternative 4

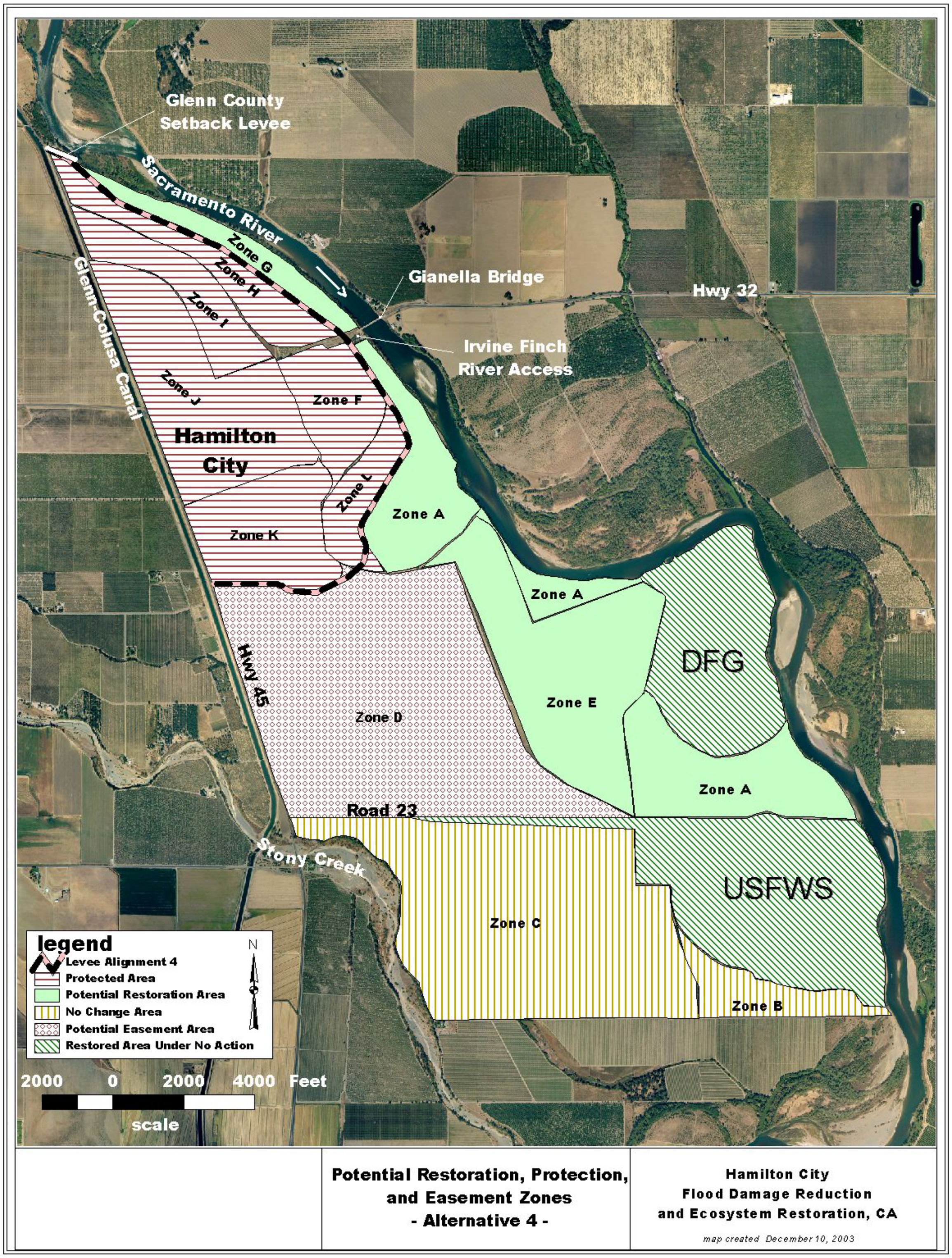


Figure 15
Alternative 5

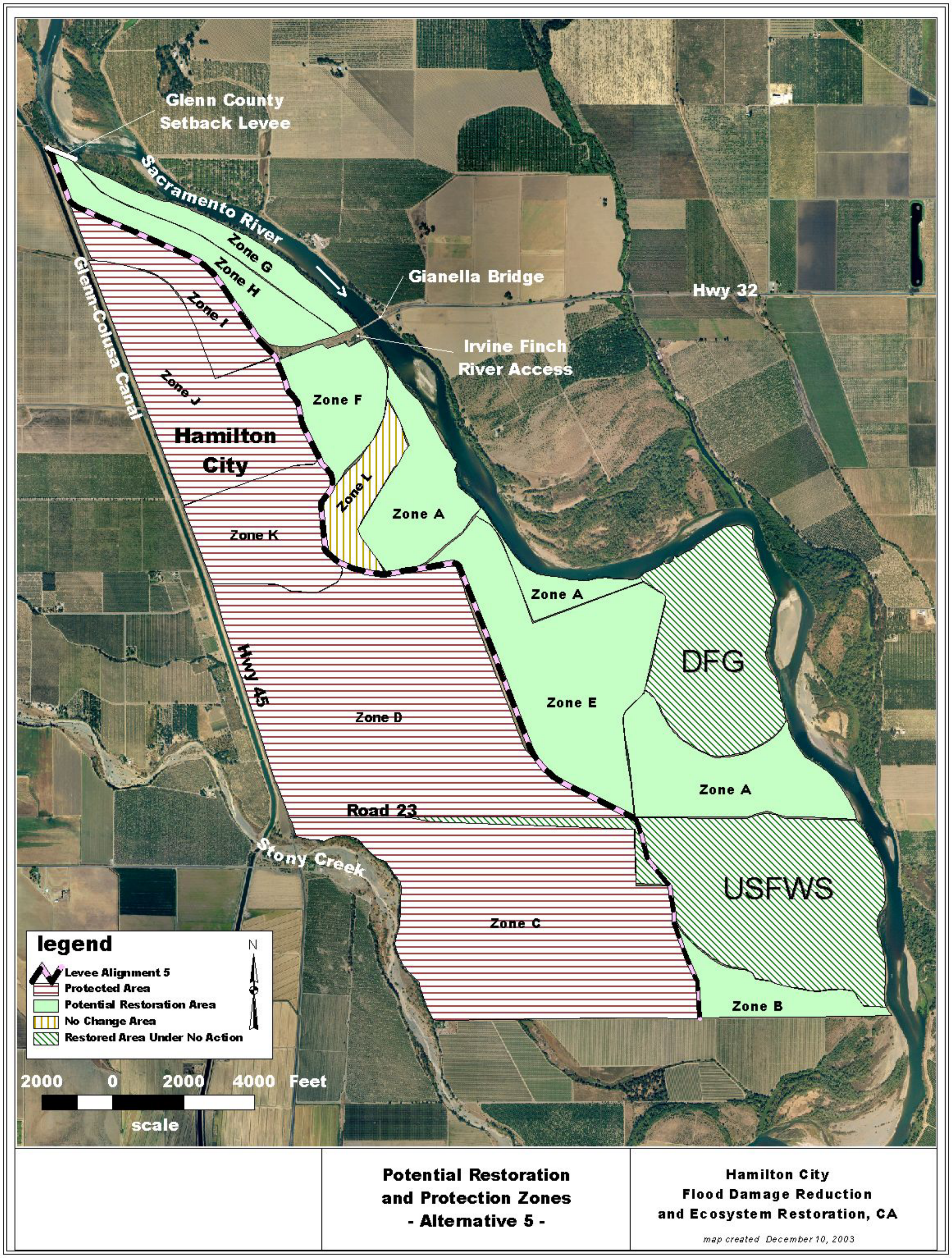


Figure 16
Alternative 6

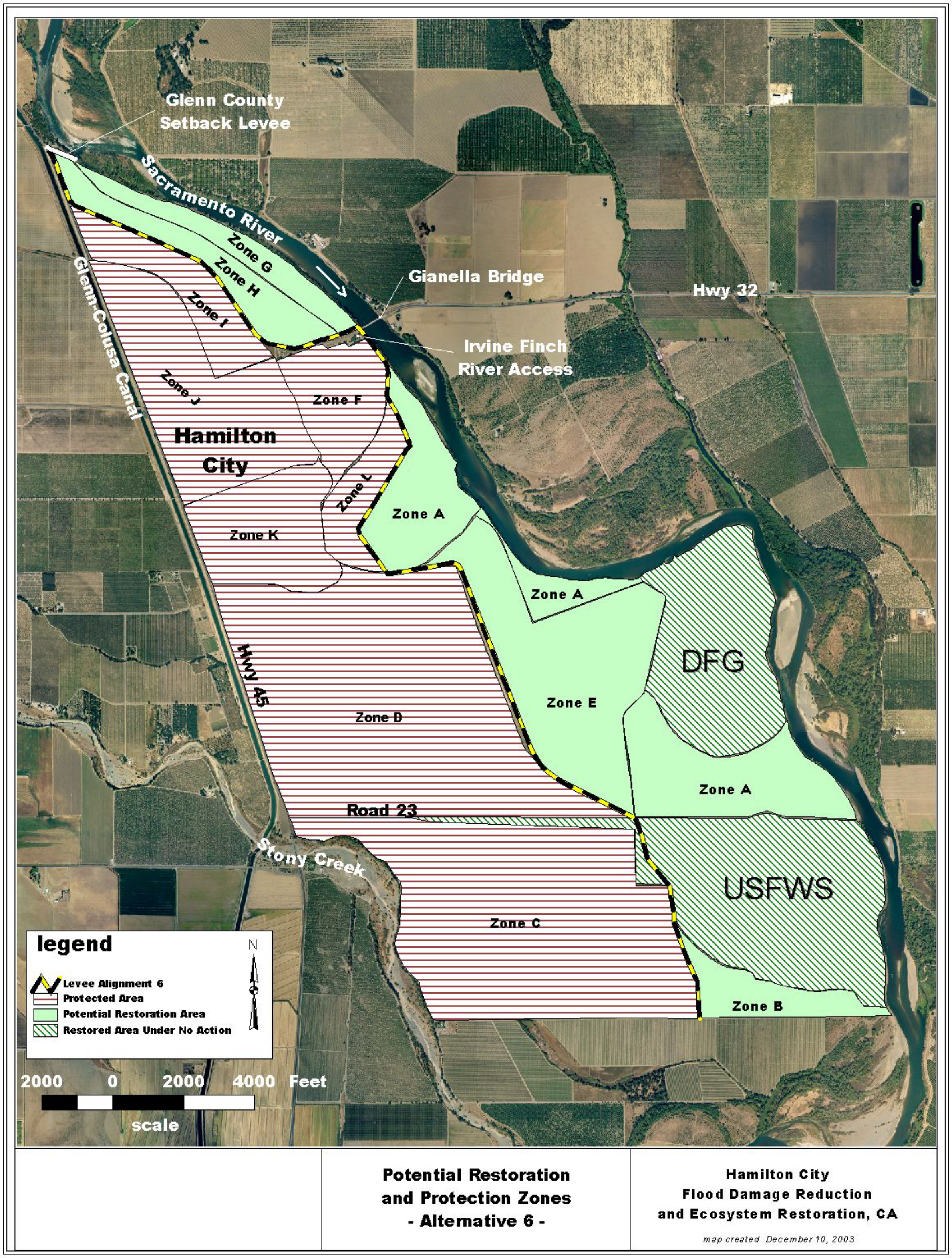
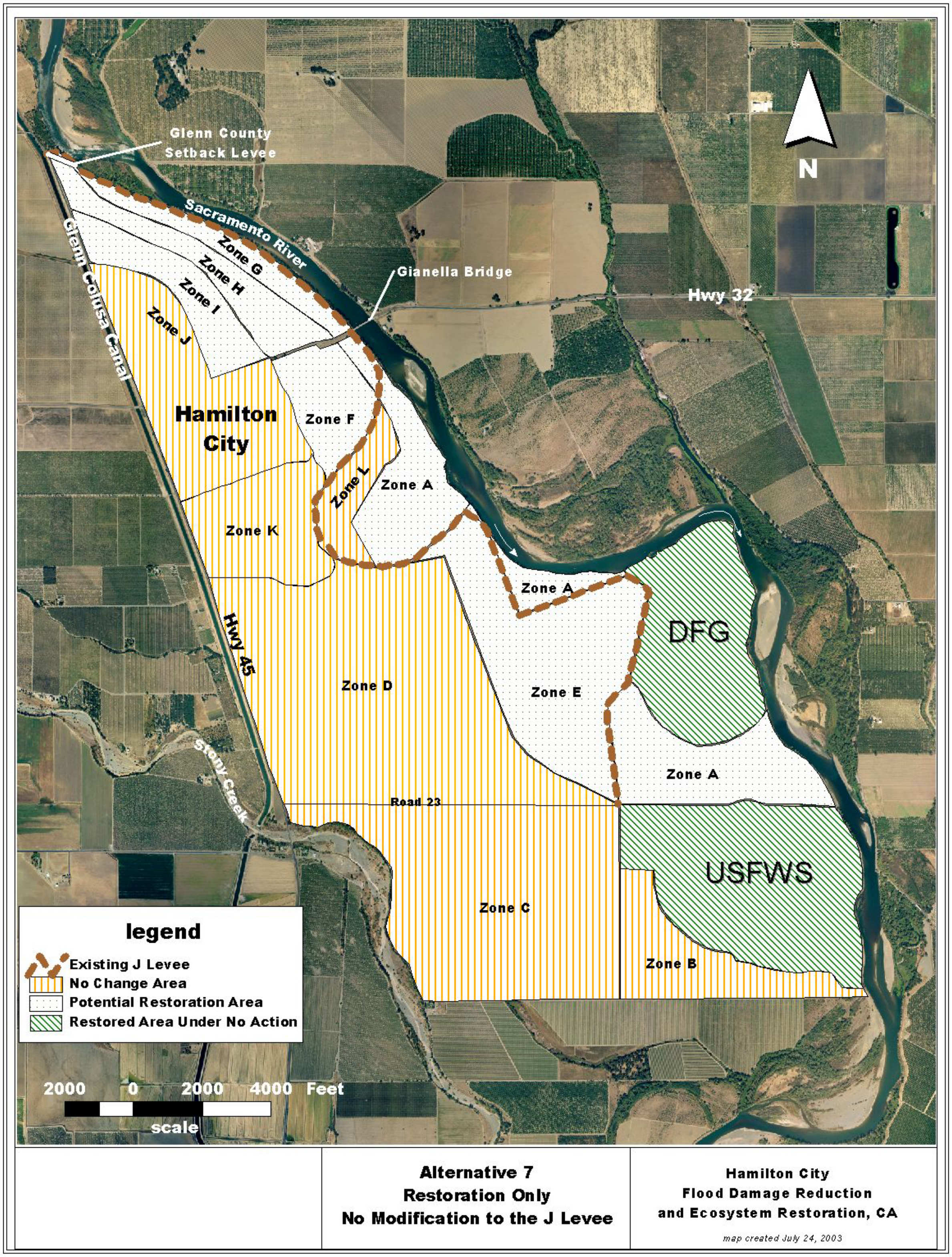


Figure 17
Alternative 7



E.4.2 Levee Failure Assumptions

In addition to the location of the alternative levee setbacks, the other key assumption involves the height of the new levee. Will it be as high as (and stronger than) the existing (but poorly functioning) levee, or shorter (and stronger) than the existing levee? It has been determined that the height of the new replacement levee should be the same as the existing "J" Levee, which is about the same as the 100-year water surface elevation [17]. Table 20 summarizes the with-project levee failure assumptions. For a new levee, the PNP and PFP are assumed to be equal to the TOL.

Table 20
Levee Failure Curves
With-Project (1)

Levee Failure Curve	2003 H&H		
	Northern (RM 198.25)	Southern #1 (RM 197.25)	Southern #2 (RM 194.25)
TOL (2)	149.2	147.1	138.9
PFP (3)	149.2	147.1	138.9
PNP (4)	149.2	147.1	138.9
TOE (5)	142.4	137.0	133.9

(1) TOL was set to the height of the existing "J" Levee.
(2) Top of levee.
(3) Probable failure point (85% chance of failure).
(4) Probable non-failure point (15% chance of failure).
(5) Toe of levee.

E.4.3 Equivalent Annual Damage

Table 21 summarizes the total equivalent annual damage estimates for the without- and with-project conditions for all alternatives in all three impact areas (assuming floodfighting). Tables 22–24 summarize the alternatives' equivalent annual damage estimates for the without- and with-project conditions for each impact area. Because the various levee alternatives include increased protection to agricultural lands landside of the levee as well as conversion of some agricultural lands to native vegetation on the waterside of the levee, the EAD reductions are actually comprised of two components: damage reduction to existing crops because of improved levee protection and damage reduction resulting from taking lands out of production and therefore removing them from the flood threat. An advantage of creating FDA files for individual analysis zones is that it allows for these two components to be identified, as shown in Tables 21-24 and Figure 18. All of the alternative plans have significant amounts of damage reduction due to improved levee protection as well as removing lands from production. However, lands that will be protected by new setback levees will still be subject to some residual risk of flooding from levee failure. In comparison,

[17] *Because a setback levee will be essentially "mitigation" for breaching the existing "J" Levee in order to accomplish ecosystem restoration, it was determined that the height of any setback levee should be the same as the "J" Levee. This height was chosen because the existing "J" Levee historically has passed flood events of this magnitude—albeit with significant floodfighting efforts.*

lands that are removed from production will not only have no residual agricultural flood damage, but they will also have additional ecosystem restoration (and possibly recreation) benefits. Chapter 3 (Plan Formulation) brings together all of the benefit and cost information for the alternatives.

E.4.4 Project Performance

Table 25 presents the with-project project performance statistics for the three impact areas. Project performance statistics were actually computed for each analysis zone, but because analysis zones within the same impact area had the same index point (i.e., the same H&H data), the project performance statistics for all analysis zones within an impact area are the same. The statistics in Table 25 can be compared with the without-project statistics in Table 17 (with floodfighting). Generally, with-project annual exceedance and long-term risk statistics should be lower than the without-project condition, and conditional non-exceedance values should be higher than the without-project condition.

Figure 18
Alternative Plans Damage Reduction: Restoration vs. Protection
All Impact Areas
TOL = 100 Year WSE
(Thousands of Dollars; October 2003 Price Levels)

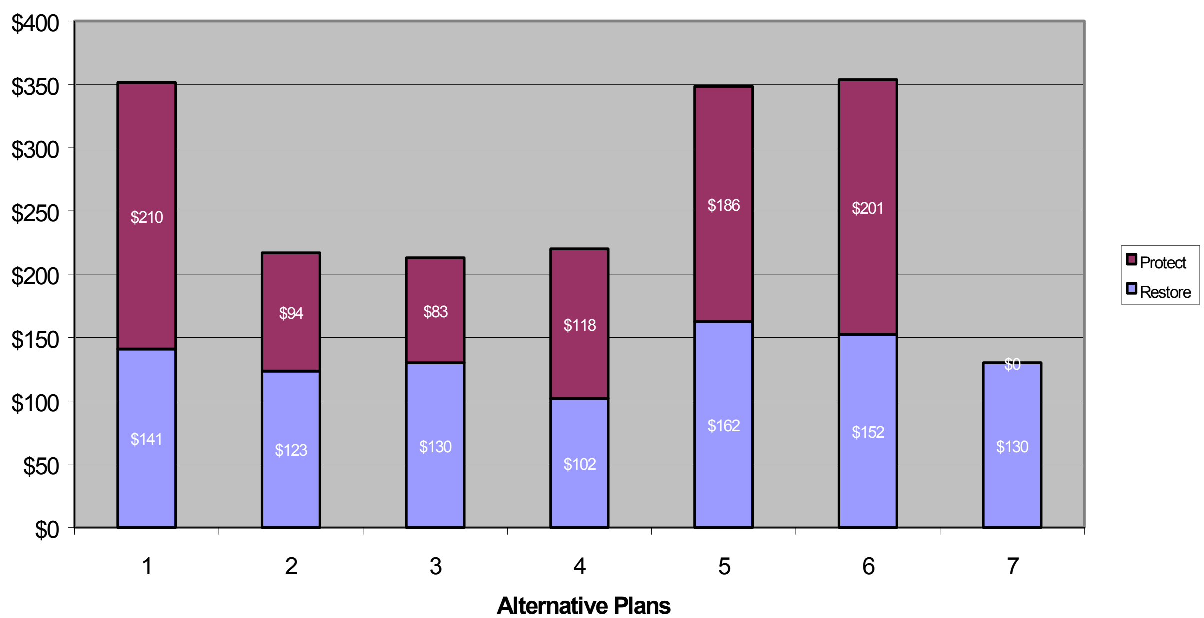


Table 21
Comparison of Alternative Plans' Equivalent Annual Damage and Damage Reduced by Project Purpose
All Impact Areas
(Thousands of Dollars; October 2003 Price Levels)(1)(2)

Plans	Equivalent Annual Damage			Damage Reduced[3]		
	Without Project	With-Project	Damage Reduced	Restore	Protect	Total
No Action	726	726	0	0	0	0
Alternative 1	726	375	351	141	210	351
Alternative 2	726	509	217	123	94	217
Alternative 3	726	513	213	130	83	213
Alternative 4	726	506	220	102	118	220
Alternative 5	726	378	348	162	186	348
Alternative 6	726	373	354	152	202	354
Alternative 7	720	596	130	130	0	130

(1) TOL for plans was set equal to the existing height of the "J" Levee (approximately 100 Yr water surface elevation (WSE) for all impact areas, including extension south of County Road 23.
(2) 5 5/8 interest rate; 50-year analysis period.
(3) Reduction in damage due to either land being restored or lands protected from new setback levee.

Table 22
Comparison of Alternative Plans' Equivalent Annual Damage and Damage Reduced by Project Purpose
Northern Impact Area
(Thousands of Dollars; October 2003 Price Levels) (1)(2)

Plan	Equivalent Annual Damage			Damage Reduced[3]		
	Without Project	With-Project	Damage Reduced	Restore	Protect	Total
No Action	407	407	0	0	0	0
Alternative 1	407	280	127	9	118	127
Alternative 2	407	283	124	30	94	124
Alternative 3	407	287	120	37	83	120
Alternative 4	407	280	127	9	118	127
Alternative 5	407	283	124	30	94	124
Alternative 6	407	278	129	21	109	129
Alternative 7	407	370	37	37	0	37

(1) TOL for plans was set equal to the existing height of the "J" Levee (approximately 100 Yr WSE).
(2) 5 5/8 interest rate; 50-year analysis period.
(3) Reduction in damage due to either land being restored or lands protected from new setback levee.

Table 23
Comparison of Alternative Plans' Equivalent Annual Damage and Damage Reduced by Project Purpose
Southern #1 Impact Area
(Thousands of Dollars; October 2003 Price Levels) (1)(2)

Plan	Equivalent Annual Damage			Damage Reduced[3]		
	Without Project	With-Project	Damage Reduced	Restore	Protect	Total
No Action	130	124	0	0	0	0
Alternative 1	130	17	113	46	67	113
Alternative 2	130	84	46	46	0	46
Alternative 3	130	84	46	46	0	46
Alternative 4	130	84	46	46	0	46
Alternative 5	130	17	113	46	67	113
Alternative 6	130	17	113	46	67	113
Alternative 7	130	84	46	46	0	46

(1) TOL for plans was set equal to the existing height of the "J" Levee (approximately 100 Yr WSE).
(2) 5 5/8 interest rate; 50-year analysis period.
(3) Reduction in damage due to either land being restored or lands protected from new setback levee.

Table 24
Comparison of Alternative Plans' Equivalent Annual Damage and Damage Reduced by Project Purpose
Southern #2 Impact Area
(Thousands of Dollars; October 2003 Price Levels) (1)(2)

Plan	Equivalent Annual Damage			Damage Reduced[3]		
	Without Project	With-Project	Damage Reduced (3)	Restore	Protect	Total
No Action	189	189	0	0	0	0
Alternative 1	189	78	111	86	25	111
Alternative 2	189	143	47	47	-	47
Alternative 3	189	143	47	47	0	47
Alternative 4	189	143	47	47	0	47
Alternative 5	189	78	111	86	25	111
Alternative 6	189	78	111	86	25	111
Alternative 7	189	143	47	47	0	47

(1) TOL for plans was set equal to the existing height of the "J" Levee (approximately 100 Yr WSE).
(2) 5 5/8 interest rate; 50-year analysis period.
(3) Reduction in damage due to either land being restored or lands protected from new setback levee.

Table 25
Project Performance Statistics
With-Project (1)
TOL = 100 Year WSE

Impact Area	**Annual Exceedance Probability (Expected)**	**Long Term Risk (Years)**			**Conditional Non-Exceedance Probability by Events**					
		10	**25**	**50**	**10% (1 in 10 years)**	**4% (1 in 25 years)**	**2% (1 in 50 years)**	**1% (1 in 100 years)**	**0.40% (1 in 250 years)**	**0.20% (1 in 500 years)**
Northern	0.0170 (2%)	0.1570 (16%)	0.3476 (35%)	0.5744 (57%)	0.9991 (100%)	0.9099 (91%)	0.7213 (72%)	0.4290 (43%)	0.1256 (13%)	0.0207 (2%)
Southern #1(2)	0.0130 (1%)	0.1200 (12%)	0.2735 (27%)	0.4722 (47%)	0.9994 (100%)	0.9632 (96%)	0.8101 (81%)	0.5283 (53%)	0.1991 (20%)	0.0585 (6%)
Southern #2 (2)	0.0140 (1%)	0.1318 (13%)	0.2976 (30%)	0.5067 (51%)	0.9998 (100%)	0.9448 (94%)	0.7848 (78%)	0.5052 (51%)	0.1621 (16%)	0.0279 (3%)

(1) Reflects risk of levee failure only and does not include risk of backwater flooding.
(2) Statistics for these impact areas are for analysis zones located behind levees; analysis zones restored on the water side of the levees will have a greater risk of flooding.

E.4.5 Backwater Flood Damage Analysis

Backwater flooding occurs when floodwater creeps around the southern end of the existing "J" Levee and fills in low-lying (primarily agricultural) lands to the north in the Southern impact area #1. Although not protected by the existing "J" Levee, the Southern impact area #2 is also subject to backwater flooding from lands further to the south. Backwater flooding can reach as far north as the southern edge of Dunning Slough (on the *landside* of the "J" Levee) and it typically occurs more frequently than flooding from levee failures. However, backwater flooding does not usually occur with the higher flood velocities associated with levee failure flooding (which can flow quickly through narrow breaks in levees), so damage tends to be less. Figure 9 shows the estimated existing backwater floodplains from water flowing around the southern end of the existing "J" Levee. If the "J" Levee were to be extended further south (as in some of the alternatives), backwater flooding would still be present although the floodplains would shift southward.

Figure 10 illustrates the differences in levee failure vs. backwater flooding. Areas subject to levee failure flooding include I and II, with water originating from the river breaching the "J" Levee. In contrast, backwater flooding flows around the southern edge of the "J" Levee (through area III) and up into area II. Total flood damage should then be computed for areas I + II + III. But, these cannot be simply added together. Using Figure 10 as an example, adding damage in areas flooded by levee failures (I and II) to areas flooded by backwater flooding (II and III) double counts damage occurring in area II.

The extents of the two types of floodplains (levee failure and backwater) may not always match (for example, as shown in Figure 10). Sometimes the extent of the backwater flooding may occur entirely within the extent of the levee failure floodplain, sometimes just the opposite, or they may overlap unevenly. To avoid expending significant amounts of time and resources studying the backwater flooding issue, a simplifying assumption was made that one of the floodplains (levee failure or backwater) is always contained within the other. Given this assumption, damage estimates from the levee failure and backwater flooding scenarios were computed separately using FDA, and the larger estimate of the two was taken as the damage estimate for that analysis zone.

Table 26 illustrates this analysis for economic analysis zones C and D.[18] For economic analysis zone D, without-project equivalent annual damage is estimated to be about $84,000. This damage results from the potential failure of the southern portion of the existing "J" Levee. This zone is also subject to backwater flooding as water creeps north around the southern end of the existing "J" Levee, causing an equivalent annual damage estimated to be about $21,000. With-project levee failure equivalent annual damage is estimated to be about $17,000 (for the 100-year water surface elevation levee height) compared to backwater equivalent annual flood damage of about $3,000. Because the potential levee failure damage is greater than the backwater flood damage for the without- and with-project conditions, the reduction in damage is computed by taking the difference between the levee failure damage and ignoring backwater flood damage. Thus, for the 100-year WSE levee height, the annual reduction in damage (i.e., benefit) of the proposed levee height is about $67,000.

[18] *Economic analysis zone D is located within the Southern #1 impact area and zone C is located within the Southern #2 impact area. Other economic analysis zones are located within these impact areas, however they are located to the east of the proposed levee alignment. Thus they will be restored and will have no remaining "with-project" residual flood damage. See Figures 3 and 16.*

The analysis is different for economic analysis zone C. This zone is located south of County Road 23, which is below the southern extent of the existing "J" Levee. Existing without-project equivalent annual damage resulting from levee failure flooding is estimated to be about $103,000. This zone is also subject to backwater flooding from water coming north from lands located to the south; this equivalent annual damage is estimated to be about $78,000. Although a levee extension into this zone (with a height equal to the 100-year WSE) will reduce potential levee failure equivalent annual flood damage to about $8,000, this reduction in damage cannot be achieved because of the continued presence of backwater flooding. Thus, the maximum benefit that could be achieved is about $25,000—the difference between levee failure and backwater flood damage. This benefit can be achieved with a relatively low-height levee (at about the 5 year-WSE). Levee heights above this would not appear to gain additional economic benefits.

An interesting observation concerns the reduction in with-project backwater flood damage in economic analysis zone D. The existing "J" Levee terminates at the southern end of this impact area (at County Road 23), which allows the backwater flooding to flow around this southern end and back north into the impact area. With the proposed levee extension south of County Road 23, this backwater flooding still occurs, but the extent and magnitude of the flooding is reduced as the backwater floodplain is shifted to the south. Figure 19 shows the "with-project" backwater floodplains, which can be compared to Figure 9, which shows the "without-project" backwater floodplains. The floodplains in Figure 19 have shifted to the south compared to the floodplains in Figure 9.

Thus, the backwater equivalent annual flood damage in economic analysis zone D is reduced from about $21,000 to about $3,000 (or a benefit of $18,000) with the levee extension. When this benefit ($18,000) is combined with the reduction in "overbank" damage in economic analysis zone C from the levee extension (about $25,000), the total equivalent annual damage reduction from the levee extension is obtained—about $43,000.

Table 26
Backwater Flood Damage Analysis
Economic Analysis Zones D and C
(Thousands of Dollars; October 2003 Price Levels)

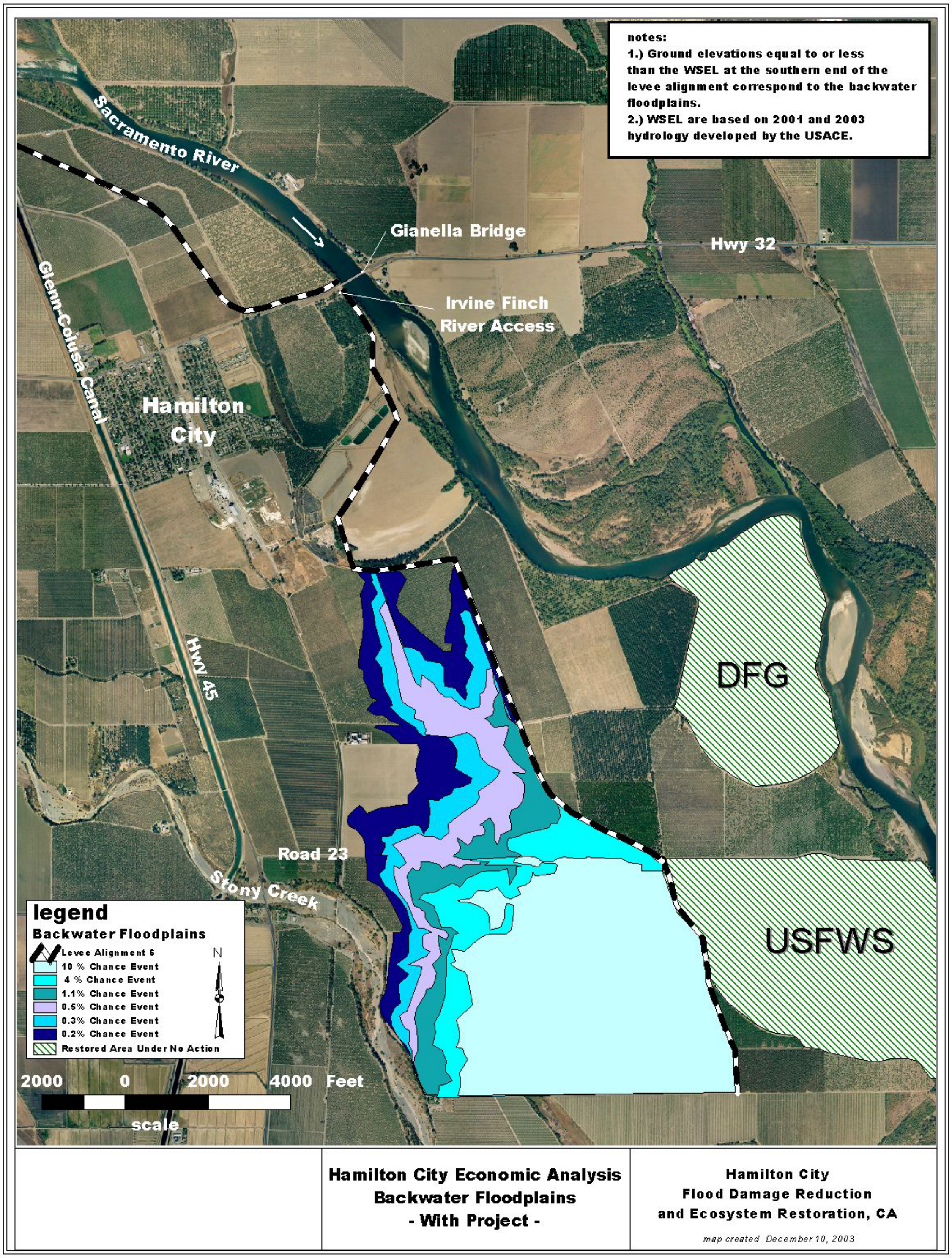
Economic Analysis Zone D (Southern #1 Impact Area)

WSE	W/O Project		With-Project		Damage Reduction
	Levee Failure	Backwater	Levee Failure	Backwater	
200	84	21	10	3	74
100	84	21	17	3	67
50	84	21	25	3	59
25	84	21	37	3	47

Economic Analysis Zone C (Southern #2 Impact Area)

WSE	W/O Project		With-Project		Damage Reduction
	Overbank	Backwater	Levee Failure	Backwater	
100	103	78	8	78	25
50	103	78	13	78	25
25	103	78	23	78	25
10	103	78	52	78	25
5	103	78	72	78	25

Figure 19
Hamilton City Economic Analysis Floodplains
Backwater Flooding
With-Project



E.4.6 Identification of the Final Array of Alternatives

Although the Hamilton City project will address flood damage reduction and ecosystem restoration purposes, recent Corps guidance[19] requires that:

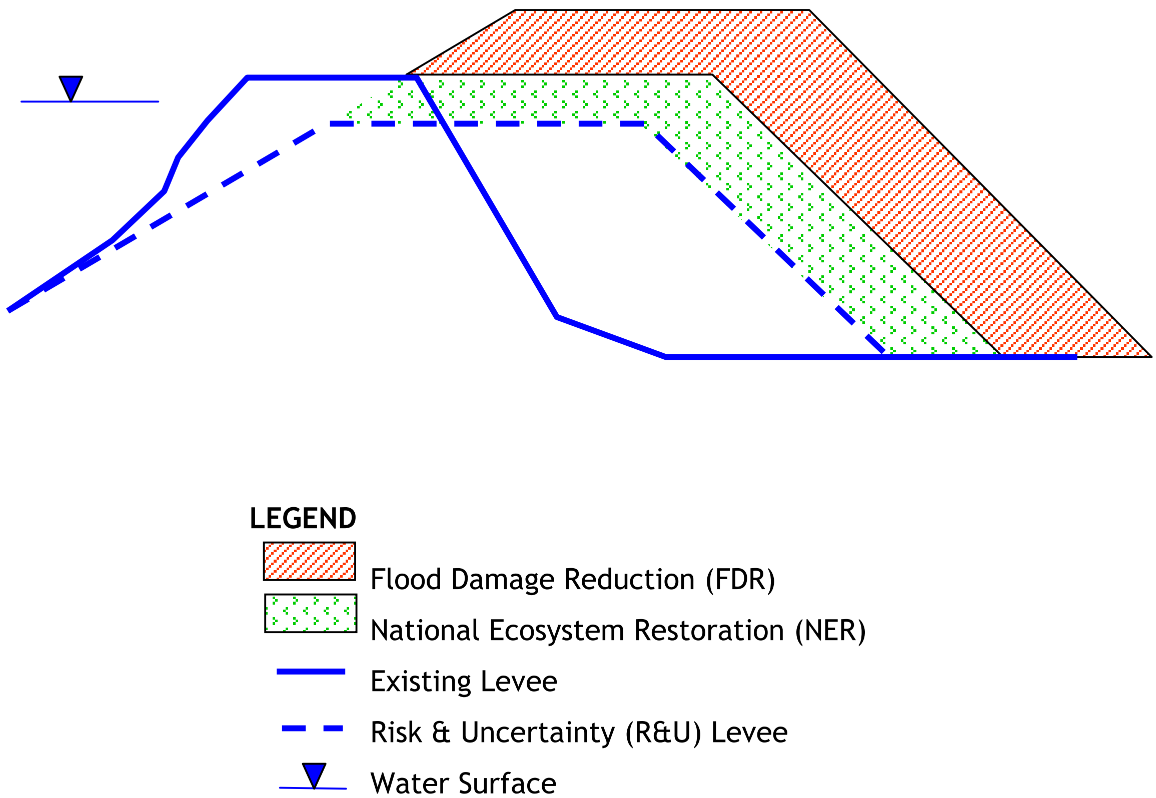
- Plans first be formulated that address the *primary* purpose of the study,
- After the primary purpose has been identified, develop the NER (National Ecosystem Restoration) or NED (National Economic Development) combined plan, and then
- Formulate plans that address other problems and opportunities as well as the primary purpose.

For Hamilton City, the primary purpose has been identified as ecosystem restoration (NER). All of the alternatives discussed previously (with the exception of the No Action alternative) have ecosystem restoration as their primary purpose. Through the plan formulation process described in Chapter 3, the final array of combined NER/FDR alternatives that will be evaluated further (in addition to No Action) include Alternative 1, Alternative 5, and Alternative 6. These alternatives combine both flood damage reduction and ecosystem restoration objectives.

A setback levee is required for some ecosystem restoration-only plans to avoid induced flooding of lands outside of the project site caused by the intentional breaching of the "J" Levee. Therefore, it was necessary to determine at what elevation this replacement levee should be built. One procedure that could be used by the Corps would be to set the elevation of a replacement levee such that the annual exceedance (i.e. failure) probability for the replacement levee should be about the same as the existing levee. If this "risk and uncertainty" approach were to be followed, the elevation of the replacement levee would be considerably less than the existing "J" Levee. However, because of significant floodfighting efforts, the existing "J" Levee has the **possibility** of passing large events, a possibility which would not exist if a lower replacement levee were constructed. In addition, there are social and legal considerations (for example, obtaining State Reclamation Board approval) that would make a lower replacement levee unacceptable and unimplementable. Thus, as discussed in Chapter 3, it has been determined that the elevation of any setback levee for an ecosystem restoration-only plan should be the same elevation as the "J" Levee, which is close to the 100-year water surface elevation. This determination is consistent with previous Corps practice and received HQUSACE and SPD concurrence during the AFB conference. Figure 20 illustrates these concepts.

[19] *EC 1105-2-404, "Planning Civil Works Projects Under The Environmental Operating Principles", 1 May 2003.*

Figure 20
Hamilton City NER Levee Elevation Analysis



1 Note: The R&U Levee (Replacement) will meet the performance of the existing levee but is susceptible to overtopping at lesser flows than the existing levee. The NER levee meets Reclamation Board requirements. The NER levee is also based on social and political considerations that have to be included for project implementation. The FDR Levee provides the NER requirements and provides protection from higher flows thereby negating too-typical flood fighting efforts.

E.4.7 Levee Elevations and Incremental Flood Damage Reduction Benefits

Given this recommended NER levee elevation, the question remains if it would be economically feasible to raise any selected setback levee above the 100-year water surface elevation in order to provide additional flood damage reduction (FDR) benefits. Thus, for the final array alternatives, FDA was run incorporating the 200-, 320-, and 500-year water surface elevations plus the estimated FEMA certification levee elevation shown in Table 27 (assuming that PNP = PFP = top of levee).[20] Levee elevations greater than the 100-year water surface elevation were not analyzed for the Southern #2 impact area levee extension because they would protect primarily agricultural lands.

Table 27
Northern and Southern #1 Impact Areas
Levee Elevations (Feet)

Impact Area	Water Surface Elevations								
	River Mile	10 Yr WSE	25 Yr WSE	50 Yr WSE	100 Yr WSE	200 Yr WSE	320 Yr WSE	FEMA Cert	500 Yr WSE
Northern	198.25	145.7	147.9	148.4	149.5 (1)	150.4	150.8	151.2	152.3
Southern #1	197.25	143.2	144.9	145.9	147.1	147.9	148.0	148.8	149.1
Southern #2	194.25	135.4	136.98 (3)	137.9	138.9	N.A (2)	N.A (2)	N.A (2)	N.A (2)

(1) Within FDA, TOL was set equal to 149.2, which is the top of the "J" Levee at that river mile.
(2) Not analyzed above the 100 year WSE.
(3) 20 year WSE.

The results of this incremental FDR benefit analysis are shown in Tables 28–30 for the final array alternatives. In the section "Average Annual Benefits", these tables present:

- Residual flood damage remaining for the different setback levee heights;
- Flood damage reduction (compared to the without-project condition) for each of the levee heights;
- Avoided floodfight costs (assuming average weather conditions);
- Total annual FDR benefits, which are the sum of flood damage reduction and the avoided floodfight costs; and
- Incremental FDR benefits between successive levee height increases.

[20] *FEMA and the Corps have agreed to criteria for certifying that a levee would be able to pass a 100-year (1% chance) flood event. Although the criteria vary somewhat depending upon local circumstances, they basically state that a levee must have at least a 90 percent chance of passing the 100-year (1%) flood event. This flood event is a critical threshold for the National Flood Insurance Program, because development within the 100-year (1% chance) floodplain is subject to NFIP development regulations and flood insurance requirements. It should be pointed out that in order to achieve the 90 percent confidence of passing the 100-year flood event, the levee usually must be designed at an elevation greater than the 100-year flood event because we can not predict with certainty exactly where the 100-year water surface elevation is likely to be.*

Under "Average Annual Costs", these tables present:

- Total levee first costs, which are the estimated construction costs for the different levee heights;
- Total FDR levee first costs, which are the construction costs allocated to the FDR purpose (primarily increased levee volume costs above the NER plan plus rock erosion protection costs);
- Annualized total levee and FDR-allocated first costs; and
- Incremental FDR costs between successive levee height increases.

The tables also show the average annual FDR net benefits (which are the difference between annualized FDR benefits and costs), incremental FDR net benefits, FDR benefit/cost ratios and two key project performance statistics for the Northern impact area, which includes the community of Hamilton City. Figures 21– 29 graphs the B/C ratios, FDR net benefits, and annual net benefits vs. annual FDR costs. For Alternatives 1, 5 and 6, net benefits decrease for levee heights above the 320-year water surface elevation.

Since the evaluation of the preliminary combined plans, initial hydraulic runs have been completed which suggest potential hydraulic impacts on the left bank (east side) of the Sacramento River if levee elevations in the Southern #1 and #2 impact areas are too high. Consequently, the final array alternatives were reevaluated using decreasing levee elevations for the three impact areas: Northern, 320-year water surface elevation; Southern #1, 100-year water surface elevation; and Southern #2, 20-year water surface elevation (training levee). The resulting without- and with-project flood damage reduction benefits for the final array alternatives are shown in Table 31. The selection of the recommended combined plan (Alternative 6) is discussed in Chapter 3, which takes into account ecosystem restoration benefits and costs, flood damage reduction benefits and costs, and potential hydraulic impacts across the Sacramento River. The project performance statistics for the without project condition and the recommended plan (Alternative 6) are summarized in Tables 32 and 33.

Table 28
Alternative 1 FDR Levee Elevation Analysis
(Thousands of Dollars; October 2003 Price Levels)

Benefits and Costs	Without Project (1)	100 Yr WSE NER Only (2)	Combined NER + FDR Plans			
			100 Yr WSE With Train. Levee (3)	200 Yr WSE With Train. Levee (3)	320 Yr WSE With Train. Levee (3)	500 Yr WSE With Train. Levee (3)
Levee Elevations (FT)						
Northern Impact Area	149.2	149.2	149.2	150.4	150.8	152.3
Southern #1 Impact Area	145.3	147.1	147.1	147.9	148	149.1
Southern #2 Impact Area	133.9 Bank	138.9	138.9	138.9 (4)	138.9 (4)	138.9 (4)
Average Annual Benefits						
Residual Flood Damage	$726	$418	$375	$285	$257	$164
Flood Damage Reduction	-----	$308	$351	$441	$469	$562
Avoided Floodfight Costs (5)	-----	$114	$114	$114	$114	$114
Annual FDR Benefits	-----	$422	$465	$555	$583	$676
Incremental Annual FDR Benefits	-----	$0	$43	$90	$28	$93
Average Annual Costs						
Total Project First Costs (6)	-----	$42,006	$42,006	$42,154	$42,343	$44,273
Total FDR First Costs	-----	$0	$685	$834	$1,024	$2,956
Annual Project Costs (7)	-----	$2,525	$2,525	$2,533	$2,545	$2,661
Annual FDR Costs (7)	-----	$0	$41	$50	$62	$178
Incremental Annual FDR Costs	-----	$0	$0	$9	$11	$116
Average Annual FDR Net Benefits (7)	-----	$422	$424	$505	$521	$498
Incremental Annual FDR Net Benefits	-----	$0	$2	$81	$17	-$23
FDR Benefit/Cost Ratio	-----	-----	11.30	11.07	9.47	3.81

Project Performance Statistics						
90% Confidence of Passing *x* Event						
Northern Impact Area	< 10 yr	26 yr	26 yr	59 yr	75 yr	190 yr
Southern #1 Impact Area	< 10 yr	35 yr	35 yr	58 yr	62 yr	146 yr
Southern #2 Impact Area	< 10 yr	37 yr	37 yr	NA	NA	NA
Annual Exceedance Probability						
Northern Impact Area	0.0860	0.0170	0.0170	0.0070	0.0050	0.0010
Southern #1 Impact Area	0.1310	0.0130	0.0130	0.0070	0.0060	0.0030
Southern #2 Impact Area	0.2370	0.0140	0.0140	NA	NA	NA

(1) Assumes floodfighting except for the Southern #2 impact area which has no existing levee
(2) Assumed mitigation levee elevation (NER Plan); no training levee
(3) Includes training levee south of County Road 23 (Southern #2 Impact Area)
(4) Not analyzed above the 100 WSE
(5) Assuming average weather conditions
(6) Excludes cultural resource preservation.
(7) 5 5/8 interest rate; 50 yrs

Table 29
Alternative 5 FDR Levee Elevation Analysis
(Thousands of Dollars; October 2003 Price Levels)

Benefits and Costs	Without Project (1)	100 Yr WSE NER Only (2)	Combined NER + FDR Plans			
			100 Yr WSE With Train. Levee (3)	200 Yr WSE With Train. Levee (3)	320 Yr WSE With Train. Levee (3)	500 Yr WSE With Train. Levee (3)
Levee Elevations (FT)						
Northern Impact Area	149.2	149.2	149.2	150.4	150.8	152.3
Southern #1 Impact Area	145.3	147.1	147.1	147.9	148	149.1
Southern #2 Impact Area	133.9 Bank	138.9	138.9	138.9 (4)	138.9 (4)	138.9 (4)
Average Annual Benefits						
Residual Flood Damage	$726	$421	$378	$292	$265	$174
Flood Damage Reduction	-----	$305	$348	$434	$461	$552
Avoided Floodfight Costs (5)	-----	$114	$114	$114	$114	$114
Annual FDR Benefits	-----	$419	$462	$548	$575	$666
Incremental Annual FDR Benefits	-----	$0	$43	$86	$27	$91
Average Annual Costs						
Total Project First Costs (6)	-----	$49,035	$49,035	$49,343	$49,545	$51,486
Total FDR First Costs	-----	$0	$685	$994	$1,197	$3,138
Annual Project Costs (7)	-----	$2,947	$2,947	$2,966	$2,978	$3,094
Annual FDR Costs (7)	-----	$0	$41	$60	$72	$189
Incremental Annual FDR Costs	-----	$0	$0	$19	$12	$117
Average Annual FDR Net Benefits (7)	-----	$419	$421	$488	$503	$477
Incremental Annual FDR Net Benefits	-----	$0	$2	$67	$15	-$26
FDR Benefit/Cost Ratio	-----	-----	11.22	9.17	7.99	3.53

Project Performance Statistics						
90% Confidence of Passing *x* Event						
Northern Impact Area	< 10 yr	25 yr	26 yr	59 yr	75 yr	190 yr
Southern #1 Impact Area	< 10 yr	35 yr	35 yr	58 yr	62 yr	146 yr
Southern #2 Impact Area	< 10 yr	37 yr	37 yr	NA	NA	NA
Annual Exceedance Probability						
Northern Impact Area	0.0860	0.0170	0.0170	0.0070	0.0050	0.0010
Southern #1 Impact Area	0.1310	0.0130	0.0130	0.0070	0.0060	0.0030
Southern #2 Impact Area	0.2370	0.0140	0.0140	NA	NA	NA

(1) Assumes floodfighting
(2) Assumed mitigation levee elevation (NER Plan); no training levee
(3) Includes training levee south of County Road 23 (Southern #2 Impact Area)
(4) Not analyzed above the 100 WSE
(5) Assuming average weather conditions
(6) Excludes cultural resource preservation.
(7) 5 5/8 interest rate; 50 yrs

Table 30
Alternative 6 Levee Elevation Analysis
(Thousands of Dollars; October 2003 Price Levels)

Benefits and Costs	Without Project (1)	100 Yr WSE NER Only (2)	Combined NER + FDR Plans: 100 Yr WSE With Train. Levee (3)	200 Yr WSE With Train. Levee (3)	320 Yr WSE With Train. Levee (3)	500 Yr WSE With Train. Levee (3)
Levee Elevations (FT)						
Northern Impact Area	149.2	149.2	149.2	150.4	150.8	152.3
Southern #1 Impact Area	145.3	147.1	147.1	147.9	148	149.1
Southern #2 Impact Area	133.9 Bank	138.9	138.9	138.9 (4)	138.9 (4)	138.9 (4)
Average Annual Benefits						
Residual Flood Damage	$726	$416	$373	$294	$256	$164
Flood Damage Reduction	-----	$310	$353	$432	$470	$562
Avoided Floodfight Costs (5)	-----	$114	$114	$114	$114	$114
Annual FDR Benefits	-----	$424	$467	$546	$584	$676
Incremental Annual FDR Benefits	-----	$0	$43	$79	$38	$92
Average Annual Costs						
Total Project First Costs (6)	-----	$43,191	$43,191	$43,419	$43,615	$45,610
Total FDR First Costs	-----	$0	$685	$912	$1,109	$3,106
Annual Project Costs (7)	-----	$2,596	$2,596	$2,609	$2,621	$2,741
Annual FDR Costs (7)	-----	$0	$41	$55	$67	$187
Incremental Annual FDR Costs	-----	$0	$0	$14	$12	$120
Average Annual FDR Net Benefits (7)	-----	$424	$426	$491	$517	$489
Incremental Annual FDR Net Benefits	-----	$0	$2	$65	$26	-$28
FDR Benefit/Cost Ratio	-----	-----	11.34	9.96	8.76	3.62

Project Performance Statistics						
90% Confidence of Passing *x* Event						
Northern Impact Area	< 10 yr	26 yr	26 yr	59 yr	75 yr	190 yr
Southern #1 Impact Area	< 10 yr	35 yr	35 yr	58 yr	62 yr	146 yr
Southern #2 Impact Area	< 10 yr	37 yr	37 yr	NA	NA	NA
Annual Exceedance Probability						
Northern Impact Area	0.0860	0.0170	0.0170	0.0070	0.0050	0.0010
Southern #1 Impact Area	0.1310	0.0130	0.0130	0.0070	0.0060	0.0030
Southern #2 Impact Area	0.2370	0.0140	0.0140	NA	NA	NA

(1) Assumes floodfighting except for the Southern #2 impact area which has no existing levee
(2) Assumed mitigation levee elevation (NER Plan); no training levee.
(3) Includes training levee south of County Road 23 (Southern #2 Impact Area)
(4) Not analyzed above the 100 WSE
(5) Assuming average weather conditions
(6) Excludes cultural resource preservation.
(7) 5 5/8 interest rate; 50 yrs

Figure 21
Alternative 1 FDR Levee Elevation Analysis
B/C Ratios

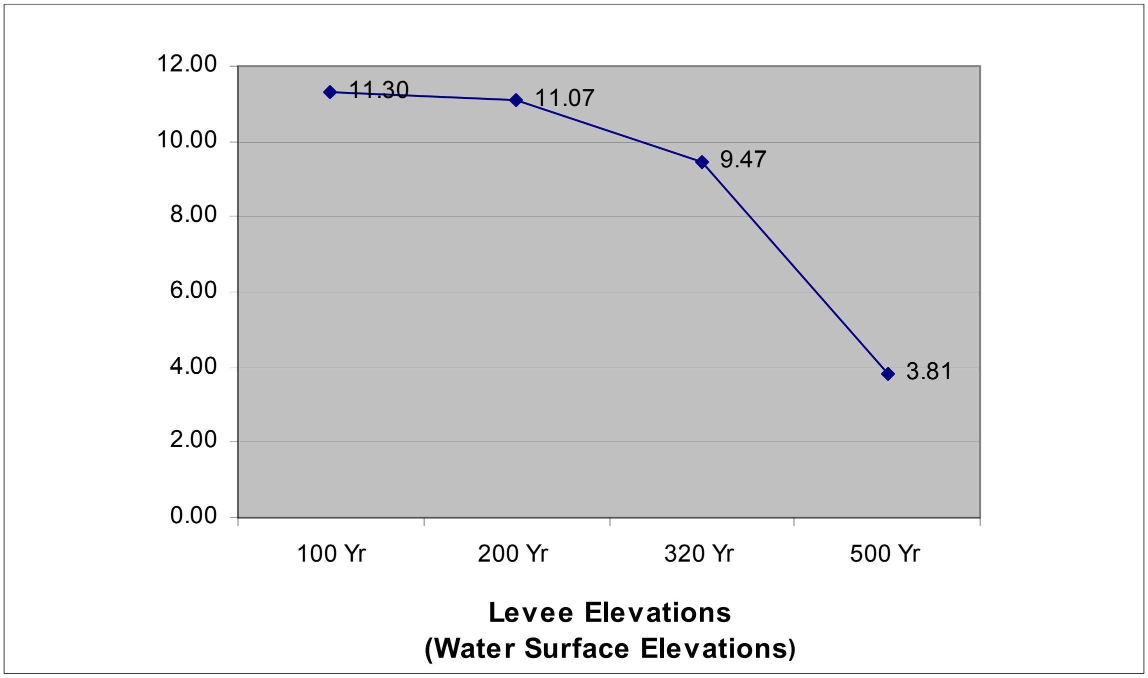


Figure 22
Alternative 1 FDR Levee Elevation Analysis
Annual Net Benefits
(Thousands of Dollars; October 2003 Price Levels)

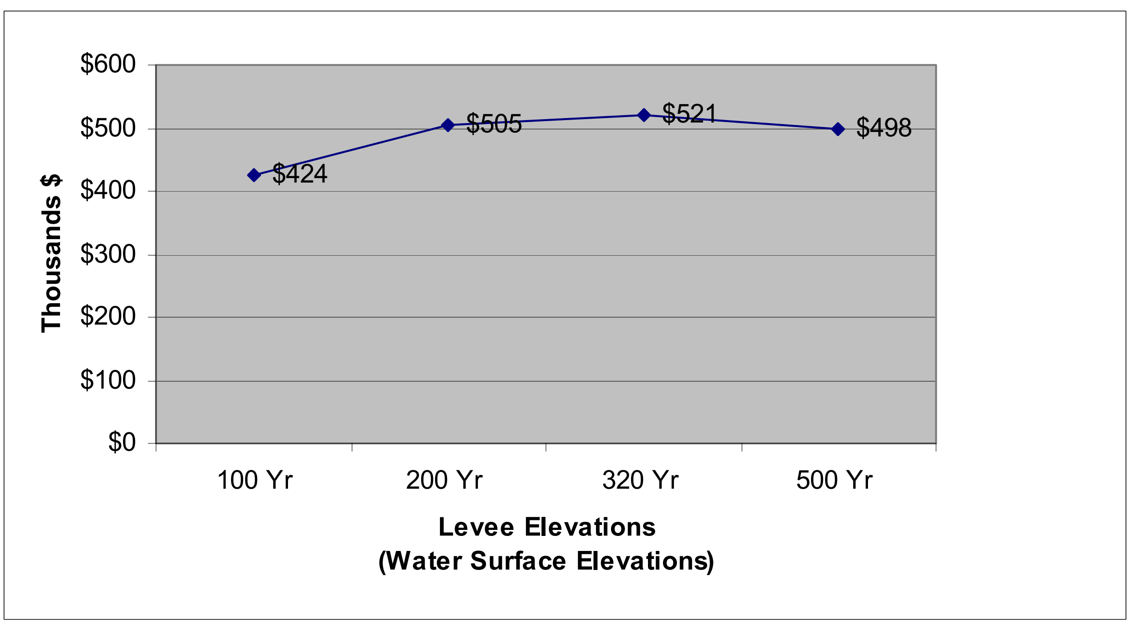


Figure 23
Alternative 1 FDR Levee Elevation Analysis
Annual FDR Benefits vs. FDR Costs
(Thousands of Dollars; October 2003 Price Levels)

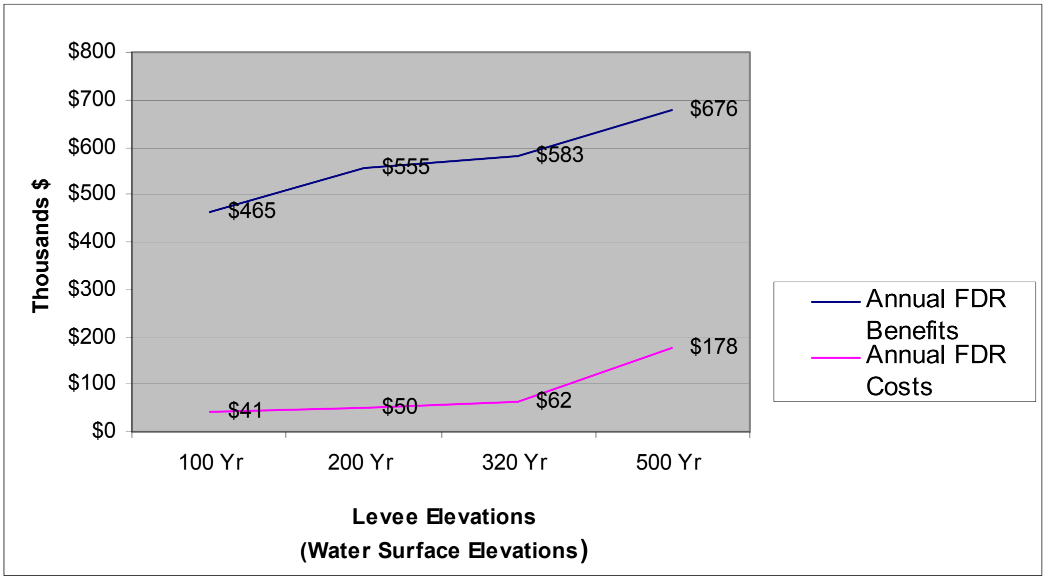


Figure 24
Alternative 5 FDR Levee Elevation Analysis
B/C Ratios

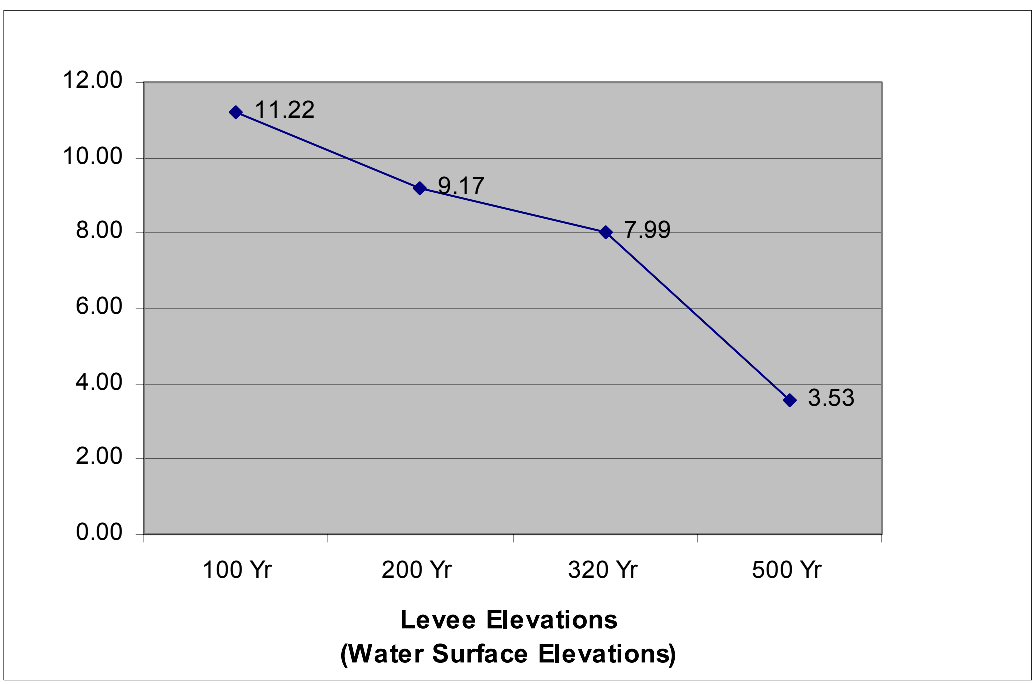


Figure 25
Alternative 5 FDR Levee Elevation Analysis
Annual Net Benefits
(Thousands of Dollars; October 2003 Price Levels)

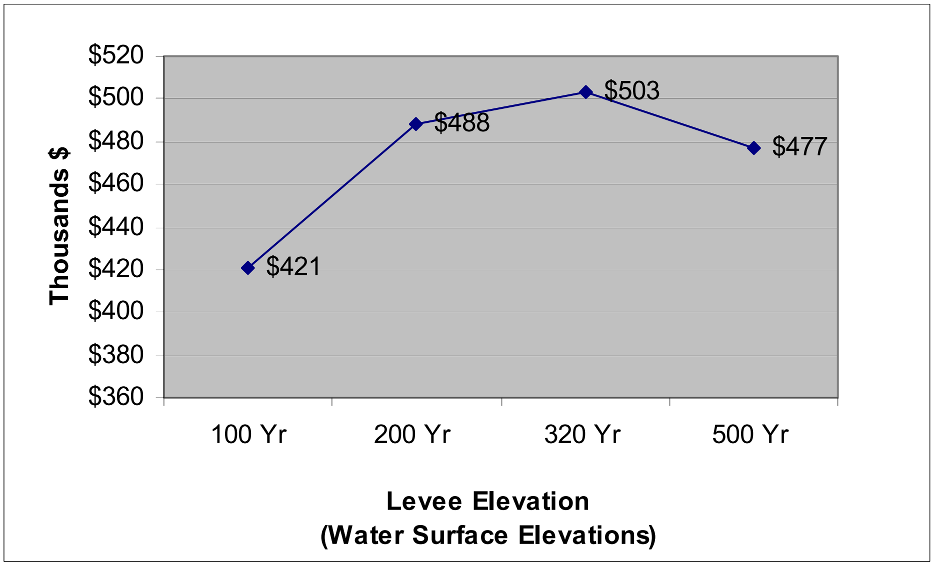


Figure 26
Alternative 5 FDR Levee Elevation Analysis
Annual FDR Benefits vs. FDR Costs
(Thousands of Dollars; October 2003 Price Levels)

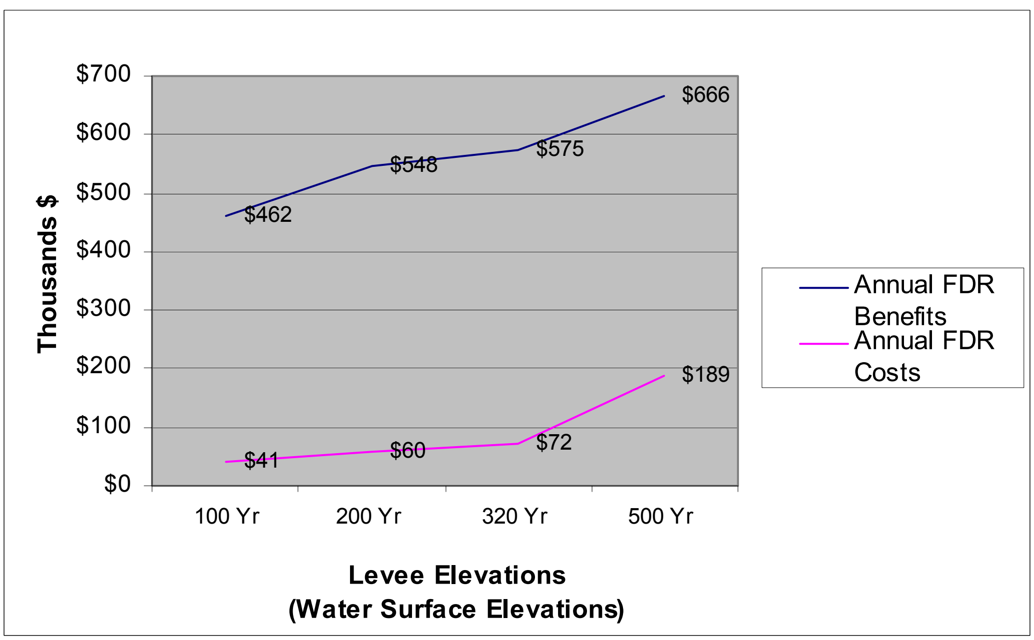


Figure 27
Alternative 6 FDR Levee Elevation Analysis
B/C Ratios

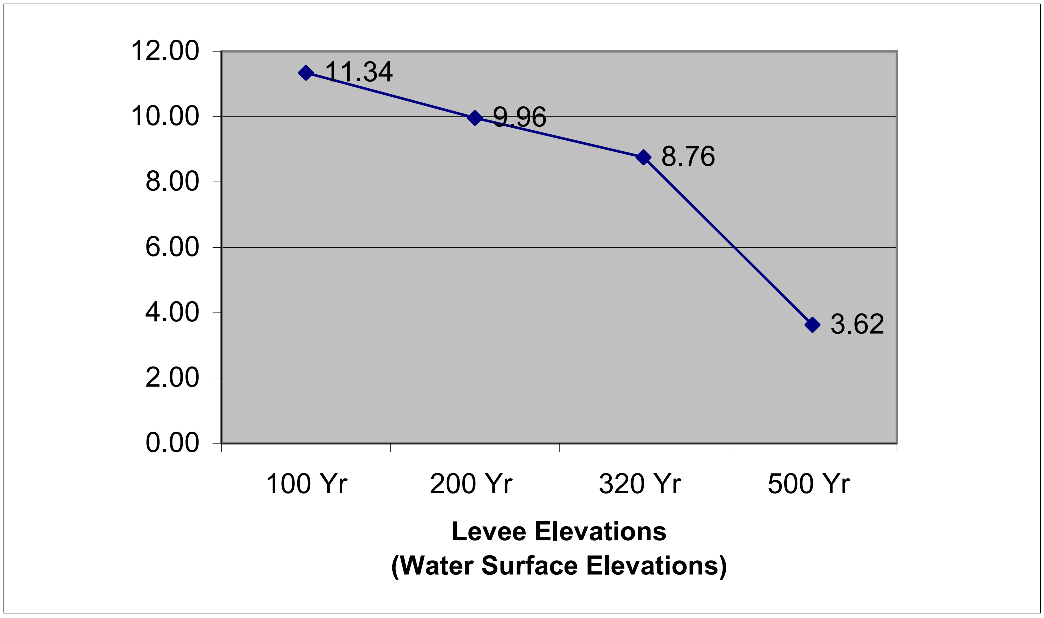


Figure 28
Alternative 6 FDR Levee Elevation Analysis
Annual Net Benefits
(Thousands of Dollars; October 2003 Price Levels)

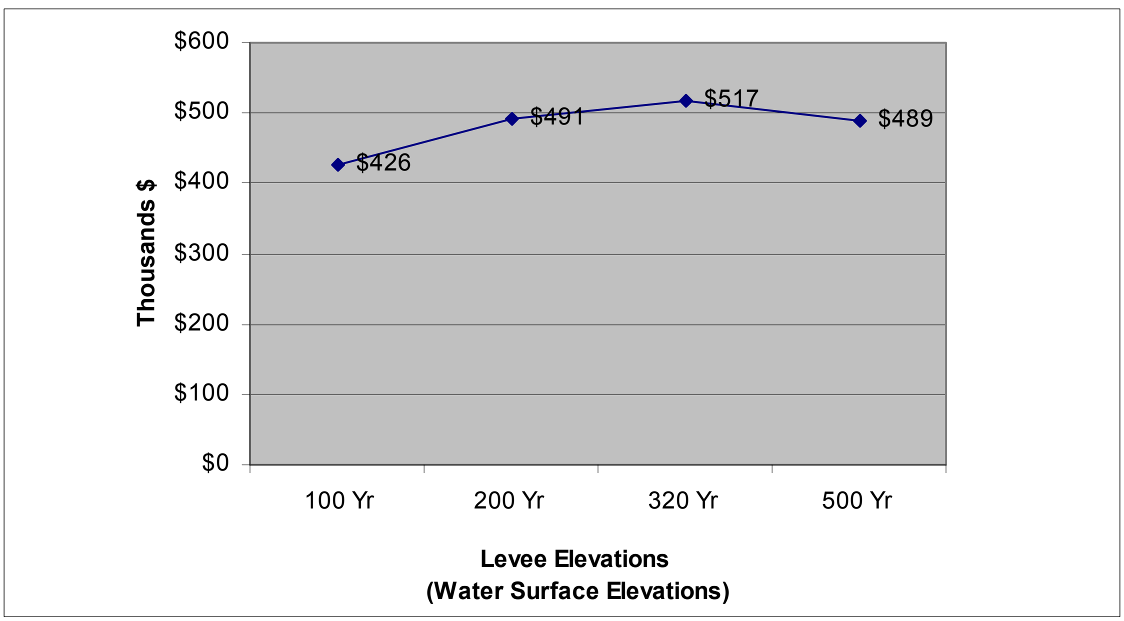


Figure 29
Alternative 6 FDR Levee Elevation Analysis
Annual FDR Benefits vs. FDR Costs
(Thousands of Dollars; October 2003 Price Levels)

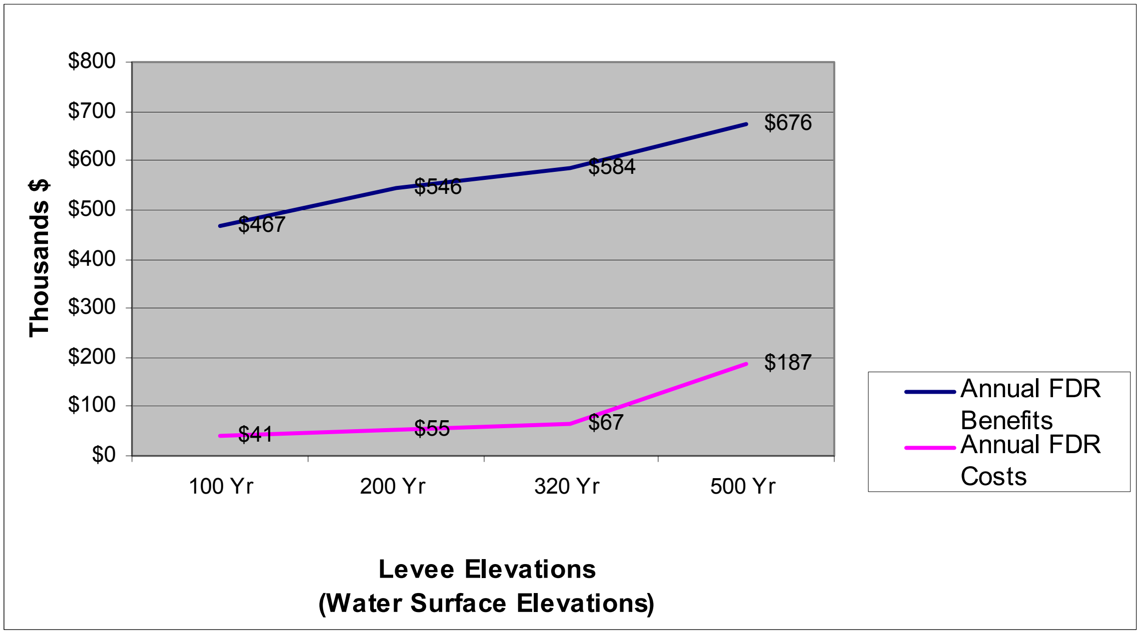


Table 31
Final Array Alternatives
Annual FDR Benefits with Decreasing Levee Elevations
(Thousands of Dollars; October 2003 Price Levels)

Plans	Equivalent Annual Damage			Avoided Floodfight Costs	Total FDR Benefits
	Without Project (1)	With Project (2)	Damage Reduced		
No Action	726	726	0	0	0
Alternative 1 (2)	726	264	462	114	576
Alternative 5 (2)	726	272	454	114	568
Alternative 6 (2)	726	263	463	114	577

(1) Includes floodfighting.
(2) TOL =
Northern 320 Yr WSEL
Southern #1 100 Yr WSEL
Southern #2 20 Yr WSEL

Table 32
Project Performance Statistics
Without Project
(With Floodfighting)

Impact Area	Annual Exceedance Probability (Expected)	Long Term Risk (Years)			Conditional Non-Exceedance Probability by Events					
		10	25	50	10% (1 in 10 years)	4% (1 in 25 years)	2% (1 in 50 years)	1% (1 in 100 years)	0.40% (1 in 250 years)	0.20% (1 in 500 years)
Northern	0.0860 (9%)	0.5929 (59%)	0.8942 (89%)	0.9888 (99%)	0.6628 (66%)	0.2157 (22%)	0.0956 (10%)	0.0349 (3%)	0.0057 (0.5%)	0.0006 (0.06%)
Southern #1	0.1310 (13%)	0.7548 (75%)	0.9702 (97%)	0.9991 (100%)	0.4643 (46%)	0.1317 (13%)	0.0447 (4%)	0.0117 (1%)	0.0025 (0.3%)	0.0002 (0.02%)
Southern #2	0.2370 (24%)	0.9335 (93%)	0.9989 (100%)	1.0000 (100%)	0.0663 (7%)	0.0025 (0.3%)	0.0006 (0.1%)	0.0001 (0.0%)	0.0000 (0.0%)	0.0000 (0.0%)

Table 33
Project Performance Statistics
With Project

Impact Area	Annual Exceedance Probability (Expected)	Long Term Risk (Years)			Conditional Non-Exceedance Probability by Events					
		10	25	50	10% (1 in 10 years)	4% (1 in 25 years)	2% (1 in 50 years)	1% (1 in 100 years)	0.40% (1 in 250 years)	0.20% (1 in 500 years)
Northern (1)	0.0050 (1%)	0.0492 (5%)	0.1184 (12%)	0.2228 (22%)	1.0000 (100%)	0.9957 (100%)	0.9624 (96%)	0.8368 (84%)	0.4914 (49%)	0.1661 (17%)
Southern #1 (2)	0.0130 (1%)	0.1200 (12%)	0.2735 (27%)	0.4722 (47%)	0.9994 (100%)	0.9632 (96%)	0.8101 (81%)	0.5283 (53%)	0.1991 (20%)	0.0585 (6%)
Southern #2 (3)	0.0490 (5%)	0.3944 (39%)	0.7145 (71%)	09185 (92%)	0.9309 (93%)	0.4554 (46%)	0.2012 (20%)	0.0618 (6%)	0.0073 (1%)	0.0007 (0.1%)

(1) TOL = 320 year WSE
(2) TOL = 100 year WSE
(3) *TOL = 20 year WSE*

E.5 CONCLUSIONS

The objectives of the Hamilton City project are to improve ecosystem conditions along the Sacramento River and to reduce flood damage in the community of Hamilton City and surrounding agricultural areas. This appendix summarizes the flood damage analysis of without- and with-project conditions. The Study Team evaluated seven combined alternatives consisting of flood damage reduction and ecosystem restoration measures (in addition to the no action alternative). All seven alternatives include a new levee setback (of different lengths) to replace the existing "J" levee. Because the primary purpose of the project has been identified as ecosystem restoration, it was determined that any new replacement "mitigation" setback levee should have an elevation similar to the existing "J" levee, or about the same as the 100-year water surface elevation. South of Hamilton City, the new setback levee may be built to shorter elevations, because it will be protecting primarily agricultural lands.

For the entire study area, the estimated without-project condition equivalent annual damage is about $726,000 (October 2003 price levels). Of this total, about $313,000 is damage to structures and contents. The without-project damage estimate assumes extensive floodfighting of the existing "J" levee, which reduces flood damage. It also includes allowances for backwater flooding which creeps around the southern end of the "J" levee and floods lands to the north (on the landside of the levee). All seven combined alternatives result in equivalent annual damage reductions ranging from $130,000 to $354,000 (with levee elevations set approximately to the100-year water surface elevation). The largest flood damage reduction is for Alternative 6. Of the total flood damage reduction for this alternative, about $202,000 is attributable to improved protection for lands that are to the west (landside) of the new setback levee, compared to about $152,000 which results from taking lands out of production because of restoration activities on the waterside of the new setback levee.

An incremental flood damage reduction analysis was conducted to determine if it would be economically feasible to raise the setback levee above the 100-year water surface elevation. Based upon this analysis, the net benefits of increasing levee elevations for Alternative 6 (the recommended plan) and the other final array alternatives increase up to the water surface elevation that may be sufficient to acquire FEMA certification (i.e., protection from the 1%, or 1 in 100, chance event). However, a hydraulic analysis is currently being conducted to show the maximum elevation to which the levee can be raised without causing any negative hydraulic impacts on the east bank of the Sacramento River or further downstream. Preliminary results from this hydraulic analysis indicate that it is at least possible to raise the levee up to the 320-year water surface elevation in the Northern impact area (which includes the community of Hamilton City), which would not be sufficient to acquire FEMA certification. To avoid negative hydraulic impacts, levee elevations in the Southern #1 and Southern #2 impact areas would need to be lower, possibly at the 100-yr and 20-yr water surface elevations, respectively.